THE AMERICAN GAS LIGHT JOURNAL

REDMANKENNY, N.Y.

PUBLISHING OFFICE No. 32 PINE STREET

DEVOTED TO THE INTERESTS OF ILLUMINATION, VENTILATION, WATER SUPPLY AND DISTRIBUTION, & GENERAL SCIENCE.

VOLUME LXIII.—No. 19. Whole No. 1,065. | NEW YORK, MONDAY, NOVEMBER 4, 1895. | $3 PER ANNUM, IN ADVANCE.

A. M. CALLENDER & CO., Proprietors. C. E. SANDERSON, Manager.
JOS. R. THOMAS, C.E., Editor. T. J. CUNNINGHAM, Asst. Editor.

ENTERED AT THE POST OFFICE AT NEW YORK, N. Y., AS SECOND-CLASS MATTER.

Published on each Monday of the year, at No. 32 Pine Street, New York.

Terms of Subscription, Including Postage—For the United States and Canada, $3 per annum. European countries, £4.5) (19 shillings—22½ francs). All payments to be made in advance. Single copies, 10 cents.

Remittances should be made either by post office order, express money order, registered letter, or bank draft on New York, payable to the order of A. M. Callender & Co.

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[OFFICIAL NOTICE.]

November Meeting, Guild of Gas Managers.

OFFICE OF THE SECRETARY, November 1, 1895.

The November meeting of the Guild of Gas Managers will be held in Young's Hotel, Boston, Mass., at noon, of Saturday, the 9th inst.

A. K. QUINN, Secretary.

[OFFICIAL NOTICE.]

November Meeting, Society of Gas Lighting.

OFFICE OF THE SECRETARY, November 1, 1895.

The November meeting of the Society of Gas Lighting will be held in the works of the Mutual Gas Light Company, New York City, at 3 P.M. of Thursday, the 14th inst. FRED. S. BENSON, Secretary.

BRIEFLY TOLD.

DEATH OF MR. JAMES A. HADLEY.—We regret to be called upon to chronicle the death of Mr. James A. Hadley, late Superintendent and Purchasing Agent of the Meriden (Conn.) Gas Light Company, who passed away during the night of October 21st. Deceased, who was in his 68th year, was a native of New Orleans, La., and eventually settled in Meriden, shortly after the close of the War of the Rebellion. He attached himself to the Meriden Gas Light Company, according to the records at our command, in the winter of 1866, which corporation was at that time far from robust, but with the growth of the city came prosperity to the Company, and not a little of its success is attributable to Mr. Hadley's careful and intelligent methods of handling its affairs. The result of his labors in its behalf is shown by its financial standing to-day. Some years ago the Company engaged in the supply of electrical currents, and Mr. Hadley also had supervising charge of this branch of its business. He was an active member of the New England Association of Gas Engineers, and although he was never particularly prominent in its politics, he was nevertheless a frequent attendant of its meetings. Personally he was a most estimable man, and enjoyed the esteem of the community that he served for well on to a third of a century. The funeral services were held at his late residence, South Colony street, Meriden, on the afternoon of October 24th, the Reverend A. T. Randall officiating. On the conclusion of the religious services, St. Elmo Commandery, K. T., directed by Senator John Walter Mix, E. C., assumed charge of the funeral, and the Commandery escorted the remains to Walnut Grove Cemetery, where the interment was made according to the ritual. The pall bearers were: Major L. Coe, Dr. G. H. Wilson, and Messrs. E. C. Birdseye, H. Wales Lines, George H. Miller and Theodore M. Byxbee. The floral offerings were many and beautiful, notable pieces being those presented by the Directors of the Gas Light Company and the employees of the electric light station. For the facts above given we are indebted to "Observer."

MR. HUMPHREYS' PAPER ON THE "COMMERCIAL VALUE OF PHOTOMETRY."—In the current installment of our abstract of the proceedings

of the Philadelphia meeting is given the admirable paper by Mr. Alex. C. Humphreys, on the important subject of the "Commercial Value of Photometry." We give it in full, although some of the matter (notably that contained in Exhibit "E," most of which will be found in our issue for July 1, 1895), has already been digested by our readers, for it would be in the nature of mangling a handsome and laborious compilation did we do otherwise. The paper does not call for criticism just now at our hands, other than is contained in the expression of opinion that the author's masterly brief is likely to give rise to some argument that shall appear in due course in the JOURNAL. All must agree, however, that Mr. Humphreys was not only masterful but conscientious in his studies and the presentation thereof; and there is scant chance for other manifestation than a smile over his pointed question, "Why should we expect the photometer to give accurate results irrespective of the observer's wishes?" Certainly, there is where the shoddy commercial value of some photometrical observations is sharply pinched. We might also add the expression of our own belief that the widening use of incandescent gas burners will not far from now cause a radical revolution in photometrical rules and methods. It is a pity that we are prevented by the rules of the Association from giving a verbatim report of the discussion that ensued, and anything less than that style of report would be as luminous as "blue gas." The speakers who participated in the debate were Messrs. Chollar, Hinman, Prichard, Somerville, A. S. Miller, Forstall, Egner, Humphreys and Dr. Love, which is sufficient guarantee that the "talk" was well-worth listening to.

NOTES.—Certain schemers have applied, or are about to apply, for the right to establish an opposition Company at Independence, Kas. Their slogan to influence the City Council and enlist the citizens is that of less than dollar gas.——The authorities of Paris, Mo., are agitating the subject of the establishment there of a gas plant to be operated on municipal account. This place is the capital of Monroe county, Mo., and is located on the Middle Fork river, at a point 44 miles southwest of Hannibal and 26 miles east and north of Moberly. It has manufactures of furniture and woollen goods, and its population does not exceed 3,000.——The officers of the Newark (N. J.) Gas Company, under the final adjustment of its executive management, are appended: H. C. Kelsey, S. H. Condict, Geo. B. Jenkinson, John L. Blake, C. A. Lighthipe, Geo. E. Halsey, E. L. Joy, A. Kirkpatrick and H. Powles; President, Henry C. Kelsey; Vice-President, S. H. Condict; Treasurer, James P. Dusenberry; Secretary, C. L. Nelson.——At the annual meeting of the Consumers Gas Company, of Toronto, Canada, the old Board of Directors was renamed. During the year the Company put in 940 new services.——In the reorganization of the Salt Lake and Ogden Gas and Electric Light Company the three Directors who stood for the English interest in the Company failed of reappointment. The new Board has the following *personnel:* W. S. McCormick, P. L. Williams, George M. Scott, L. S. Hills and T. G. Webber.——Judge Dobler, in Circuit Court No. 2, Baltimore, Md., recently issued an injunction at the instance of the Consolidated Gas Company, restraining W. B. Hoyt and the Hoyt Inspection Company from in any way interfering with the Company's meters.——The Public Lighting Committee of Bath, Me., and the proprietors of the Bath Gas and Electric Company, have agreed on a rate of $112 per arc per annum for the public lighting of that place, the schedule to be on an all night and every night basis. This is a concession of $3 per lamp per annum from the former contract price. The Hon. Frank H. Twitchell represented the Gas Company in the negotiations.

The Market for Gas Securities.

Despite the break in the general share market Consolidated held well up—in fact yesterday 100 shares were disposed of at the maximum figure of 149¼. No matter whether the dividend rate is increased or not the shares are cheap at current figures. The opening to-day (Friday) came in at 148⅞. Mutual continues to show almost abnormal strength, and Standard common has crossed the 70 mark. In fact all city gas shares are in demand at increasing figures. There is no change in the Brooklyn situation, but next week will tell a different story. Chicago gas is steady. Consumers, of Jersey City, is bid 92½, ex. div. Bay State is a bit better than last week. The firm of Close & Nash was dissolved this week by mutual consent. The regular dividend of 1½ per cent. for the last quarter has been declared by the St. Paul (Minn.) Gas Light Company. It is payable on the 12th inst. Going back, it might be said that rumor is again busy with a possibility of some sort of an agreement between the Consolidated and the New York and East River Companies. We do not put much faith in the yarn.

[Continued from page 693.]

ABSTRACT OF PROCEEDINGS, TWENTY-THIRD ANNUAL MEETING OF THE AMERICAN GAS LIGHT ASSOCIATION.

HELD AT CONTINENTAL HOTEL, PHILA., PA., OCT. 16, 17 AND 18, 1895.

FIRST DAY—AFTERNOON SESSSION.

ELECTION OF OFFICERS.

On the conclusion of the discussion on Mr. Forstall's paper, the Committee on the Nomination of Officers handed in their report. On motion of Mr. Harbison the report was accepted and its recommendations adopted. The President, in announcing the result of the ballot, declared that the following gentlemen had been chosen officers of the Association for the ensuing year:

President—C. J. R. Humphreys, Lawrence, Mass.
First Vice-President—Irvin Butterworth, Columbus, O.
Second Vice-President—C. H. Nettleton, Birmingham, Conn.
Third Vice-President—J. B. Crockett, San Francisco, Cal.
Secretary and Treasurer—A. B. Slater, Jr., Providence, R. I.
Members of Council—Two-Year Term—D. H. Geggie, Quebec, Canada; E. G. Pratt, Des Moines, Ia.; G. T. Thompson, St. Louis, Mo.; Peter Young, Knoxville, Tenn. *One-Year Term*—A. C. Humphreys, New York City; G. G. Ramsdell, Philadelphia, Pa.; J. Croul, Detroit, Mich.; and A. E. Forstall, Newark, N. J.

The President-elect, on being presented to the Association, acknowledged the compliment his fellow-members conferred upon him through their having promoted him to the highest place in their ranks. Mr. Humphreys' remarks were handsomely put, and we regret that we are barred by the Association's rulings, in respect of the publication of its proceedings, from reporting his speech verbatim.

REPORT OF COMMITTEE ON PRESIDENT'S ADDRESS.

The Committee on President's Address than handed in the following reports. The report was prepared on the afternoon of the 16th inst., and the supplemental report was submitted on the following day; but for the purpose of consecutiveness we herewith print both at this point in the proceedings:

PHILADELPHIA, Oct. 16, 1895.

MR. A. B. SLATER, JR., Secretary American Gas Light Association:

Your Committee to whom was referred the President's address have carefully considered the same, and advise that the Association take action as follows:

1. That the suggestion to abolish the "Quarterly" be approved.

2. That in the future papers be submitted, first, to the Secretary, and then to the President, and, if approved by both, that they then be published in leaflet form and mailed to each member, at the earliest date possible. That it shall be within the province of the President and Secretary to refuse to publish any part or all of any paper submitted; but any author of a paper, feeling aggrieved at such action, may submit the question to the Council, which body may, in their discretion, approve the action of the President and Secretary, or may permit the rejected matter to be read to the Association.

3. Only such papers to be discussed at the meeting of the Association as shall have been mailed to members two weeks previous to such discussion.

4. That a volume of the proceedings be published promptly after the close of each annual meeting.

5. That the Council be authorized to include in the annual volume the proceedings of other Associations, if they deem proper and can obtain from such Associations compensation therefor.

Education.

6. That an Educational Committee, or Board, be established, with a view at least of thoroughly testing the question of its utility. We do not, however, agree with the President as to the composition of the Board. Men every way qualified for President or Vice-President might, from force of circumstances, their arduous labors, or lack of taste for educational work, be wholly unfitted for serving on such a Board. We recommend that the Council appoint *three members* to constitute such Board *for active work*, and that the Junior Past President and Secretary be *ex-officio* members of the Board, and that the affirmative vote of three out of the five be necessary to authorize the expenditure of money. The Committee feel that the work suggested by the President, in the educational line, is worthy of the Association's best efforts.

7. We advise that the Association adopt the suggestion of the Presi-

dent that the Constitution be so amended as to make the test of eligibility to membership one of ability and record, rather than temporary official position.

8. While your Committee are not satisfied that anything of effective value can be accomplished by the appointment of a Committee on "Standards," yet, in deference to those members who think differently, we advise that such a Committee be appointed.

9. Your Committee desire especially to call the attention of the members to the remarks of the President respecting the importance of a more thorough discussion of papers, and to the limited number of members taking part in such discussions.

Respectfully submitted, EMERSON MCMILLIN, ALEX. C. HUMPHREYS, JAS. SOMERVILLE, } Committee.

Supplemental Report.

PHILADELPHIA, Oct. 17, 1895.

MR. A. B. SLATER, JR., Secretary American Gas Light Association:

The Committee on President's Address desire to submit the following as a supplement to the report on President's address submitted to the Association yesterday:

We advise that the Association adopt the suggestion of the President providing for a Committee on Research, and that this Committee be composed of the five members constituting the Educational Board. That this Research Committee be authorized to provide some suitable decoration to be awarded to the person submitting to such Committee the most meritorious paper on research or invention pertaining to the lighting industry.

That the Committee may make such rules as to them shall seem best for the interest of the industry and of the Association.

That persons competing for the honors must submit their papers to the Research Committee at least 60 days before the date of the annual meeting of this Association. That the Committee may provide for first and second class honors; but not more than one of each shall be conferred in any one year. That awards made by the Committee shall require the confirmation of the Council. That the affirmative action of the Council shall be regarded as the action of the Association, and make the award of the Research Committee final.

That the Committee shall not be authorized to expend the Association's money, nor to contract debts except so far as it shall be so intended by a vote of the Council; but the Committee may, at their discretion, use any money donated to them in aid of research by those desiring to aid the work, the Committee having power to receive, in the name of the Association, funds donated for such purpose.

EMERSON MCMILLIN, ALEX. C. HUMPHREYS, JAS. SOMERVILLE, } Committee.

The original report (and subsequently the supplementary report) having been adopted as read, and without discussion, the President announced that a Past-President of the Association, who declined to have his identity revealed, had offered for the purchase of prizes, to be awarded to competing members in the line of the recommendation contained in President Clark's address, the following sums: $100, for the year ending October, 1896; $200, for the year ending October, 1897; $300, for the year ending October, 1898.

On motion of Mr. Egner a hearty vote of thanks was awarded to the donor.

The President then introduced Mr. Alex. C. Humphreys, of New York, who read the following paper on

THE COMMERCIAL VALUE OF PHOTOMETRY.

Introduction.—Our President, nearly a year ago, requested me to prepare a paper for this meeting on Photometry and Illumination.

For some ten years or more this has been a peculiarly debatable field with the gas engineers of America, and of late our fellows of Great Britain have found it almost equally interesting.

Much had of late been written on the subject and of a most conflicting character, and as I knew that if I consented to again write on the subject I was expected to review the field in full, I confess I dreaded to undertake the task. I knew it would be difficult and perhaps impossible to treat the subject in any useful way within the necessary limits of an Association paper. I also knew that the subject was one which could be better handled by a physicist than by a practical gas engineer.

But as our President urged me on to the work, and as the subject is one which I considered to be of prime importance to us all, I concluded to accept the task, hoping that my efforts might result at least in shedding light on some of the dark corners and in perhaps inciting more competent minds to take up the work and carrying it through to the satisfying of us all.

Plan of Paper.—I shall first discuss the subject of illumination and photometry in general, and in connection therewith notice, more or less specifically, the points which have been made as tending to show a disagreement between "candle power," illuminating power and illuminating effect. Then I shall try to point out the safer paths to be followed in our photometrical work.

It will, no doubt, seem to some that much of what I have to say is too elementary in character. For this I shall make no apology, for it is evident that our differences are largely traceable to failure to agree as to the fundamental principles involved.

I shall employ an appendix in connection with the paper.

(1) I can so better systematize the reference data for present use.

(2) I can so bring together, in convenient shape, additional data for future general reference.

In Exhibit A I give an index of the books and papers which I have endeavored to digest in the preparation of this paper, including, I believe, nearly all that has appeared in the American and English Gas Journals during the last year or two. When an author is quoted or referred to, it may be understood that the reference can be identified by means of this index.

In Exhibit B I give a comparative table of standard units.

In Exhibit C, a recent memorandum of instruction from the London Gas Referees as to the manufacture of standard candles.

In Exhibit D, a copy of the recent report of the Photometric Standard Committee to the (English) Board of Trade.

In Exhibit E, an illustrated description of the Dibdin 10-candle pentane standard therein recommended for adoption in testing of London gas, and a memorandum of the methods employed in preparing and testing pentane.

If it is found desirable to more particularly refer to any of the items of reference in the Appendix, this can be developed in the discussion, which, I trust, will be full and unreserved.

Illumination and Photometry.—It will be remembered by many of those now present that ten years and more ago, when the contest between the coal gas and the water gas advocates was at its height, the question was raised as to the relative *illuminating* values of coal gas and water gas flames of the *same candle power*. The claim was made that a "good" 16-candle coal gas flame would give as much illumination as a 20-candle water gas flame.

Again, the rivalry between gas and electric light interests brought up this question, and the photometer has at times been discredited by gas men when the figures *seemed* to tell in favor of electric light.

And now again, our friends in Great Britain have taken up the discussion, and, as with us, we find this question tacked onto another question over which a contest is being waged, namely, the question of high candle power versus low candle power gas.

In Great Britain, therefore, and in America, in both the cases above cited, these most fundamental and important questions of candle power, illumination and photometry have been tacked onto questions necessarily partisan in their character. This is to be deplored, for the questions are sufficiently complex to merit our most thoughtful and unprejudiced consideration.

It only remains for those of us who may have reason to be prejudiced to be still more on our guard against this influence.

The first difficulty confronting us in this, as in all such discussions, is ambiguity of expression. But this is particularly a difficulty in this case for the reason that we are not agreed upon a nomenclature to be employed. Not only are we not agreed as to the names for the units and quantities involved, but we are not agreed as to the functions involved in those units and quantities.

For instance, how loosely do we employ the word "intensity," without specifying whether we have reference to the light-source or to the light waves from that source, or to the illuminated surface.

M. Blondel has proposed a scheme of units and a system of nomenclature in connection therewith, but I fear that the scheme is too elaborate for adoption by gas engineers.

But at least we can make the proper distinctions between the various functions involved, and express ourselves accordingly.

Let us, first of all, carefully distinguish between intensity of the luminous source and intensity of illumination. One refers to the cause and the other to the effect. It is true that we measure the cause by the effect, but it is none the less necessary to keep the distinction clearly in mind if we would avoid entanglement in our discussions.

We must also bear in mind the distinction between "candle power" and intensity of illumination. A 25-candle power light is of 25-candle

power, whether measured at 1 foot distance or at 4 feet; but the intensity of illumination in the first case is 16 times as great as in the second case.

We must also agree as to the meaning of quantity of light and quantity of illumination. For instance, if we have a light-source of finite dimensions (as all our light-sources are), and we can say it is giving a certain luminous effect for unity-area of surface, the *quantity* of light *emitted* will be this *intensity* multiplied by the area of the source.

If this light is received upon an enveloping hollow sphere, the total illumination will be the illumination per unit of surface (namely, the intensity of illumination) multiplied by the area of the sphere's surface.

The quantity of light emitted will be the same as the quantity received by the inner surface of the sphere, provided the sphere is filled with an absolutely transparent medium; and the *quantity* of illumination will be the same irrespective of the size of the sphere; but the *intensity* of illumination will vary inversely with the size of the sphere.

It might seem as if, to be strictly accurate, we should, when calculating quantity of light, also include the function of time, as we would in the case of the flow of gas or water.

While light does not flow, it has a duration of effect, and if by intermittent action the effect upon the retina were the same as if the light effect were constant, then, in valuing light by its effect upon the retina, in considering and comparing quantities, we would have to bring into our calculations the net time of light emission. An intermittent light-source would have an economical advantage by reason of the periods of rest. But while there is such a persistence of visual impression upon the retina, we know that such an intermittent light-source is not to be permitted on hygienic grounds, and we may dismiss time as a practical function.

Often, in connection with the comparison of lights, we find the statement made that one light has *intensity* while the other has *quantity* or *volume*. Both have intensity, high or low, and both have quantity, large or small. If the two light-sources emit the same *quantity* of light, but have unequal *intensities*, then they have areas inversely proportional to their luminous intensities. It may be difficult and even impossible to directly measure their luminous intensities and the light-giving areas, but this relation must of necessity exist. But we can measure the relative light-giving effects by studying the relative intensities of illumination produced, and so measuring, we find that smaller areas of manifestly higher luminous intensities give the same intensity of *illumination* as larger areas of manifestly lower *luminous* intensity.

Illumination is an effect produced upon the retina of the eye. The eye cannot simply by observation form a correct judgment as to intensity of illumination; but by direct comparison between two illuminated surfaces it can detect if one is more brilliantly illuminated than the other; though even then it cannot correctly estimate their relative intensities of illumination. By gradually increasing the illumination of one or decreasing that of the other surface, the eye can, within a narrow limit of error, decide when the two surfaces have been brought to the same degree of illumination. With a Rumford photometer this difference need not be more than $\frac{1}{14}$. Under proper, but readily attainable conditions, and with fairly normal eyes, this difference need not exceed $\frac{1}{100}$, or 1 per cent.; by some physicists it has been reduced nearly to $\frac{1}{500}$.

In our photometrical work we are governed by two laws which are generally stated thus:

1. The intensity of illumination on a given surface is inversely as the square of the distance from the source of light.

2. The intensity of illumination which is received obliquely is proportional to the cosine of the angle which the luminous rays make with the normal to the illuminated surface.

These two laws could be combined in one statement: The intensity of illumination on a given surface is inversely as the square of the distance from the source of light, and directly as the cosine of the angle of incidence.

With the bar photometer we are supposed to compare lights whose rays are normal to the surface, which is the disc. Then the angle of incidence is zero and the cosine 1, and so the second law can be neglected.

Referring to the first law, assume a light-source at *O*, Fig. 1 placed at the centre of the concentric spheres *A B C*, *A' B' C'* and *A'' B'' C''*. The total quantity of light emitted from the point *O* will be intercepted by the internal surface of the sphere *A B C*. If the sphere *A B C* be removed, the same quantity of light will be spread over the surface of *A' B' C'*. And if *A' B' C'* be in turn removed, the same quantity of light will be spread over the sphere *A'' B'' C''*. The quantity of light remaining the same, the intensity of illumination necessarily varies inversely with the areas of the spheres illuminated, and these areas will vary with the squares of the radii. Hence the intensity of illumination varies inversely as the squares of the distances. What is true of the spheres will be true of their proportionate parts, as, for instance, the parts cut out by the cone *A''* or *B''*.

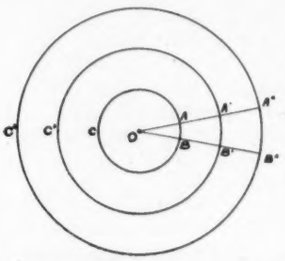


Fig. 1.—Illustrating the Law of the Inverse Squares.

The accuracy of this law, as applied to practical conditions, has been frequently disputed of late years, and as Mr. Chollar in his paper, "The Rule of the Inverse Squares," has been more than ordinarily definite in the statement of his objections, I will take his utterances as a text in this connection.

He says the law as stated is not, as is sometimes supposed, "a natural law of light," but simply depends upon the geometrical principal that the surfaces of spheres are directly as the squares of their diameters.

It is true that the law is based upon this principle, and it is also true that the demonstrations offered are usually mathematical. It is also true that scientists have for years demonstrated by experiment that the law holds good in practice.

The second, or cosine, law is also based upon a mathematical principle. A pencil of light meeting an oblique plane surface will be spread over a greater area than if meeting a surface whose plane is normal to the rays. Mathematically, the intensity should vary inversely with the increase of area. As the area increases the cosine of the angle which the ray makes with the normal to the surface will proportionately decrease and therefore be a measure of the relative intensities of illumination.

But, in this case, applying experimental tests, it was found that the law was not strictly accurate, as the reflection increased with the angle.

Thus we see that the scientific work of the laboratory which disproved the strict accuracy of the cosine law, confirmed the accuracy of the law of distances.

Mr. Chollar quotes Professor Tait's statement of the first law, and appears to be satisfied as to the accuracy of the law as thus stated, viz:

"If the medium be *transparent* the intensity of illumination *which a luminous point* can produce on a *white* surface *directly exposed* to it is inversely as the square of the distance." (The italics are mine.)

Prof. Tait here only states the law as generally understood and accepted.

Let us see if the specific statement of the limiting conditions in any way prevents us from working under the law in comparisons of light-sources. Manifestly, in such comparisons, we must agree upon what are to be considered normal conditions, just as we agree that in measuring the volume of gas we shall refer the measurements to the normal conditions, as to temperature and pressure, of 60 degrees Fahr. and 30 inches barometer.

We must first assume a transparent medium. Otherwise the same light would show differing lighting value according to the medium present, and the same medium would differently affect the light from different sources. A little thought as to the passage of light from the stars will convince us that in comparative tests it is not difficult to meet the condition as to transparency of medium. Light moves with a velocity say of 180,000 miles per second. At this velocity our earth could be encircled 7½ times in a second. Light from the fixed stars takes years to reach us and yet is then able to produce light sensation on the retina. Can we not assume then, for all practical purposes, that the ordinary transparency of our atmosphere is sufficient to meet this imposed condition?

We next come to the limitation that the light-source must be a luminous point.

Mr. Chollar evidently regards this limitation as a complete bar to the application of the law in the case of light-sources of finite dimensions. To demonstrate his proposition he assumes a line as the light-source, and then shows rays from a certain number of points in the line, converging to, and intersecting at, a point taken outside of the line. Then

he says: "Now, since light moves in straight lines, all rays starting from *A D* (the luminous line) in the direction of *E* (the point taken outside) must remain within the limits of the triangle *A E D*; sections *e e* of *A E D*, therefore, parallel with *A D* will represent aggregates of light waves or quantities of light equal to each other and equal to the total quantity emitted at *A D*."

He then goes on to say: "It appears, therefore, that, irrespective of intensity, the quantity of light from a luminous body at any particular point is independent of the distance of the body, and is in direct proportion to its diameter. If the above reasoning is correct, the total energy exerted by a light is represented by the product of two factors, one of which being increased the other can be correspondingly reduced. The rule governing the value of lights, therefore, would be something like this: The light from a luminous body is inversely as the square of its distance, and directly as its projected area."

It seems to me that Mr. Chollar is here confusing cause and effect. We measure the value of a light-source by its illuminating effect, and the law is so given even in the form approved by Mr. Chollar.

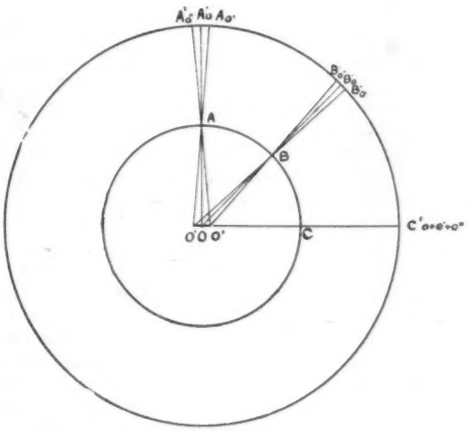


Fig. 1A.

Suppose we have three points, *O'*, *O*, *O''* (Fig. 1A) of equal luminous intensity; then, according to Mr. Chollar, there will be concentration of rays within the angle *O'*, *A*, *O''*, and this will be true of all points outside of *O'*, *O*, *O''*, except along the projection of the line *O'*, *O''*. This concentration is expected to compensate in part for the decrease of illuminating effect due to increase of distance.

But what is true of any one point, as *O*, is true of all points, and therefore of *O'*, *O''*. The light rays will, therefore, diverge equally from the points *O'*, *O*, *O''*, and will spread themselves equally over their inclosing spheres, and the resulting intensity of illumination in each case will be inversely as the squares of the radii. The intensity of illumination at *A* will be the combined intensity produced by the rays *OA*, *O'A*, *O''A*. Now suppose the luminous points *O'*, *O*, *O''* were compressed into one luminous point at *O*, resulting in one point of a luminous intensity equal to the combined intensities of *O'*, *O*, *O''*; that is, equal to three times the luminous intensity of *O*. Then we shall have the light emitted uniformly and uniformly illuminating the inside surface of sphere *A B C*, and therefore following the law of the inverse squares. But in moving *O'* and *O''* into *O* the only change we have made with regard to *A* is to shorten the distances *O'A* and *O''A*, and to that extent the combined illumination from *O'*, *O*, *O''* will differ from the combined illumination from *O'*, *O*, *O''*, as arranged in Fig. 1A to represent a luminous line. At *B* and at *C*, *O'B* and *O'C* will be longer than *OB* and *OC*, and *O''B* and *O''C* will be shorter, thus tending towards compensation, and, within working limits, enabling us to take *OB* or *OC* as the average distance. As the point *A* is moved away from the light-source, the difference in distances decreases and quickly becomes negligible. This we see when using two candles for a photometer standard. If the disc is very close to the candles inequality of illumination is apparent, and the reading fails to check with the reading from one candle multiplied by two. But moving the disc away we get a uniform illumination and a reading which will check with the single candle reading. As far as the law of the inverse squares is concerned, it makes no difference whether the illuminated surface at *A* gets its concentration of rays from one point or three, except the minor discrepancy due to difference in distances just referred to. Here we refer to effect. But if from the one point we are to obtain at *A* the same illuminating intensity as from three points of equal intensity, the one point must have three times that luminous intensity. Here we refer to cause.

Mr. Chollar says: "The *light* from a luminous body is inversely as the square of its distance, and directly as its projected area."

The *light* from a luminous body will always remain the same, irrespective of distance, until it is absorbed by some opaque body.

The intensity of illumination from a luminous body will vary inversely as the square of its distance. The *light* from a luminous body will be directly as its area (not its projected area) provided the light-source is transparent to its own rays and its luminous intensity is uniform over its entire area.

We come now to the condition that the illuminated surface must be white. No one familiar with photometry will object to this condition. In fact, it is always stipulated that the screen or disc should be white. Any deviation in this regard would be sure to work injustice to one of the lights compared, on account of the composite nature of all light. In practical illumination the light will meet surfaces possessing all possible combinations as to absorption and reflection and giving the consequent variety of color effects. We cannot expect to compose the light to suit this infinite variety of conditions and must therefore use a surface which will reflect all colors of the spectrum.

The last condition is that the surface shall be directly exposed to the light. This is necessary for the reasons just given. If the light were allowed to first fall on other surfaces, and we attempted to compare the diffused light from each source, we are again met with the point that the light from one source will be absorbed to a greater or lesser degree, depending upon the surfaces and the composite nature of the lights.

I hope I have shown that in accepting Professor Tait's careful statement of the law of the Inverse Squares, we do not have to abandon our belief in the previously accepted principles of photometry.

We have now to meet another line of attack. The claim has been repeatedly made that some kinds of light possess greater "diffusive" power than other kinds, and that there was here a departure from the law of distances, and that this departure was easily apparent to the unaided eye. If this were so it would necessarily be because the light from some parts of the spectrum penetrated distance better than from other parts. Generally the statements in this connection have been most indefinite as to argument, but none the less positive on account of that weakness. One gentleman, prominent in our discussions eight years ago, did, however, back up his position as an advocate of differences in "diffusibility" by stating that "We know that the yellow rays have greater diffusibility, and take up more room in the spectrum, than the lighter and whiter rays."

It was contended that a 16-candle coal gas light gave fully as great an illuminating effect as a 20 candle water gas. Generally this was coupled with the statement that the light from the water gas was less diffusive on account of its "greater intensity," or on account of the flame being whiter.

As some of you may remember, this was made the point for discussion in a paper entitled "Illumination vs. Candle Power," which I had the honor to read before this Association at its meeting in 1887.

In that paper I detailed the results of a series of careful experiments in which the "diffusive" power of the lights from a coal gas flame, a water gas flame and a Welsbach lamp were compared. The coal gas was of 16.5 and the water gas of 23-candle power. In these experiments the disc was set at the centre of a long table and the burners were set at equal distances on each side of the disc and then adjusted to give equal intensities of illumination. The burners were then moved out each one foot from the disc and another reading made. This was repeated foot by foot until the burners were so far removed that the illumination on the disc was reduced too low for satisfactory work. The readings remained practically constant. This proved that the light from the whiter water gas flame and from the still whiter (or greener) Welsbach "carried" as well as the light from the yellower or redder coal gas flame. (I am referring here to the *old* Welsbach.)

The recent discussions in England have been as to the relative illuminating power of flames of the same candle power. It has been claimed that the flame from a low candle gas gave a more "diffusive" light than the flame of higher candle gas, but there has not been a close agreement as to the reason for this, some contending that this claimed superiority of the low candle flame was due to lower intensity, and others claiming that it was due to a whiter flame.

This claimed difference in "diffusibility" or "carrying power" was also particularly referred to more than once, in the discussion of Mr. Newbigging's paper, "Illuminating Power and Illuminating Effect," in connection with the comparison in lighting effects of a gas flame

and a kerosene oil lamp. As in our discussions, where gas and electric lights were compared, the claimants for greater "diffusibility" were here willing, as opposed to a common competitor, to claim the advantage for gas without specifying its kind.

The kerosene lamp light is spoken of as being "less in quantity," "of greater intensity," "more concentrated and localized." Shop windows showing brilliant illumination showed no "diffusion" outside the windows as compared with gas lighted windows, &c.

The kerosene oil flame being quite different in character from either a coal gas or water gas flame, I determined to test the relative "carrying power" of the lights from these flames.

Through the courtesy of Chief Engineer Bradley and Dr. Elliott of the Consolidated Company of New York City, I was able to make the tests at their 21st street laboratory, where both water gas and coal gas are on tap. The oil lamp used was the "Belgian," and gave about 35½ candle power; (the coal gas was of about 16 and the water gas of about 27-candle power.) The same arrangement as in the experiment of 1887 was employed; sufficient gas in each case being burned to balance the light of the lamp when the first reading was made.

Dr. Elliott and his assistant agreed with me that this test failed to discover any difference in "carrying power" or "diffusibility."

The only warrant which I have been able to discover for a belief in any difference in this direction is in a minor point mentioned by Captain Abney and Professor Palaz. Captain Abney says that in the case of low intensities of illumination the eye is less sensitive to impressions from the lower, or red, end of the spectrum than from the parts higher up, and especially from the green. The difference is discoverable by illuminating a disc with red and green lights of equal intensities and then moving the lights away. The green light will keep the disc illuminated for a greater distance.

If there were a material difference in this regard, white light being composite, would to the eye give a different resultant color as we receded from the source, by reason of the retina failing to respond to the red rays equally with those from higher in the spectrum.

If there is a difference in effect upon the retina, it goes to demonstrate how completely we may be deceived by crude observations of lighting effect made without the opportunity for measurement of quantities, for the advantage as to greater "carrying power" has on this side invariably, and in England generally, been claimed for the light containing the greater proportion of the red rays.

The impressions obtained, even by experienced gas men, from these crude observations are apt to be more fanciful than valuable. We can by the eye tell if a lighting effect is pleasing or if the illumination is of a character to enable us to perform our tasks fluently, but we cannot, even approximately so, measure and compare the means employed to give the illumination observed. If in such comparisons we accept the advertised statements of candle power values of the light-sources, the responsibility for which statements is unfairly charged to the much abused photometer, then we simply invite self-deception.

It is to be noted that the men who claim the ability to make these 'practical" comparisons are often the ones who express the most contempt for the values determined by the most painstaking photometrical observations. Such "practical" observations are of no value unless we obtain the number of the light-sources and can estimate the candle power of each and the plan of distribution. We still have to account for the differences in surroundings, especially as to the relative powers of absorption and reflection of the surfaces involved. One rough test which has a value is, I think, but seldom employed—viz., the reading of different sizes of type at a given distance.

Let me as briefly as possible remind you of some of the reasons for the eye's inability to estimate illuminating values by simple inspection.

The impression of illumination which we receive is caused by excitation of the retina. This impression is not in proportion to the visual intensity energy, nor is it even in proportion to the actual illumination developed. A given amount of energy developed into visual intensity energy will give widely different results for the different parts of the spectrum. Taking dark red as 1, the yellow will be 28,000, the green 100,000, blue 62,000 and violet 1,600. But this concerns us more in connection with the economical production of light than in connection with the comparisons between the lighting values of certain light-sources, no matter how or at what cost produced.

But even here we must always bear in mind that lighting values are arbitrarily determined by the retina. If a surface is illuminated with a certain intensity, the practical result is not in proportion unless the effect on the retina is in proportion. But the retina does not act alone; the adjustable diaphragm, the iris, co-operates with the retina to prevent, as far as possible, too violent and sudden excitation of the former. If this protection is insufficient, then the retina is rendered temporarily incapable of appreciating the value of a given impression. This paralyzing effect is produced by too great an intensity of illumination; by abrupt variations in the degree of illumination; and, more than all, by the direct rays from a light-source of great intensity.

Familiar examples of this effect from each of these causes instantly occur to all of us. If we walk from bright sunlight (even diffused) into a room illuminated to a much lower degree, we are unable to recognize even the face of a friend; but, as soon as the retina has recovered somewhat from the excessive excitation produced by the bright sunlight, and the pupil has had time to expand, we find that the room is sufficiently illuminated to see all objects plainly.

If we are sitting in a rapidly moving railway car which is well enough illuminated by diffused sunlight coming through the windows on the right to enable us to read fluently, and which is further illuminated by direct sunlight coming through the windows on the left, if the latter light is intermittently obscured, say by a rapidly passing freight train moving in an opposite direction, the intervals between the cars of the latter permitting the direct sunlight to *flash* in upon as, we will find that the print is not readable. The sufficient illumination from the windows on the right is now, by contrast, darkness.

If, on a clear day, we look directly at the sun, we are, in spite of the 90,000,000 miles between us and it, rendered temporarily blind. Or, to take a less extreme case, but one very pertinent in this connection, in our work in the photometer room, if we do not shield our eyes from the direct rays of the lights under comparison, we are at first unable to make any comparison on the disc between the illuminating values of the two lights, even by this most delicate of all methods of comparison.

These homely examples you are all familiar with, and I should feel like apologizing for taking up your time in dwelling on them did I not feel sure that in our practice we fail more or less to appreciate the lessons they teach.

Let us see how this action of the eye comes in when comparing the effect from two (hypothetical) arc lamps, one naked and the other inclosed in a translucent globe. Referring to Fig. 1, let us suppose the small unlettered circle to represent a light-source 1 inch in diameter and of 1,000-candle power. This light source will, at its surface, give an illuminating intensity equal to that of 576,000 candles at 1 foot distance, or 576,000 foot candles.

Now suppose the light inclosed in the globe *A B C*, 2 feet in diameter, and suppose the luminous intensity to be just sufficiently increased to compensate for the absorption by the globe. Now we shall have at the surface of the globe an intensity of illumination of 1,000 foot candles. Therefore the candle power and the illuminating intensity at any point are not altered, but how different must be the illuminating effect if the eye is permitted to receive the direct rays, as must almost necessarily be the case in general illumination.

In one case the eye receives direct rays from a light-source producing an illuminating intensity at its surface of 576,000 foot candles, while in the second case, with equal illumination, the eye is only subjected to the direct rays from a light-source producing an illuminating intensity of 1,000 foot candles at its surface, for we may now consider the globe as a light-source.

Or, expressing it differently, with equal intensities of illumination, with the naked light the eye must receive the direct rays from a source which has only 1-576th of the projected area of the shaded light.

Suppose that when putting on the globe we do not increase the luminous intensity, and say the globe absorbs 40 per cent. of the light, then the light will be 600-candle power and only give 600 foot candles at its surface. This will present to the eye a still greater contrast as to the direct rays, and we may readily believe that for *general* illumination, with the eye taking in all the surroundings, and therefore necessarily exposed to the direct rays, the shaded light of even reduced candle power will produce the pleasanter and, therefore, the better effect. If, however, it becomes necessary to examine any object closely and continuously, we will find that by shielding our eyes from the direct rays, and waiting until the eye has recovered from excess of excitation, that the naked light of 1,000-candle power serves us better than the shaded light of 600-candle power.

Of course, in addition to the direct effect upon the eye, the larger light-source has the positive advantage of sending its converging rays in behind objects making shadows, producing a softer effect and also again relieving the eye from sharp contrasts of intensity of illumination.

Even supposing that we can correctly imitate the color of sunlight, any source of artificial illumination, subdivide and distribute it as we

may, must of necessity give imperfect results if only on account of its lack of uniformity of intensity, through the operation of the law of the inverse squares.

To take an extreme and hypothetical case, to better impress this point, let us suppose we have two light-sources, 1 inch in diameter, and placed 400 feet apart, the intensity of illumination to be measured along the horizontal upon a vertical screen. We will compare the combined illuminating effect with that of 25-candle power light-sources of the same size, set 100 feet apart.

In Fig. 2 I show graphically the effect over one-half the field. In each, the higher parts of the curves have to be omitted from the diagram for lack of room.

A few selected combined intensities of illumination, expressed in foot candles, are as follows:

	1,000-Candle Power Lights, 400 Feet Apart.	25-Candle Power Lights, 100 Feet Apart.
At the surface of the lamp..... .....576000.006		14400.0025
1 foot from center of lights.....	1000.006 +	25.00255
10 feet " "	10.0065	0.2530
20 " " "	2.5069	0.0664
50 " " " (midway between 25-candle power lights).....	0.4081	0.02
100 feet from center (surface of 2d 25-candle power lamp).....	0.111	14400.0025
200 feet from center (midway for 1,000-candle power lights).....	0.05	14400.0025
Carried over from one lamp to the next.....	0.006	0.0025
Mean intensity.....	256.	186.
Mean intensity, omitting from the calculation the intensity within sphere 1 foot radius, say "reduced mean intensity"...	10.75	1.+

Cohn, an authority on hygiene, states that the illumination produced by daylight on a well exposed table is equal to 4.6 foot candles; and that the minimum required for reading and writing without undue fatigue is about 1 foot candle.

Wybau gives as the minimum required for reading about 1 foot candle; but for fluent reading he says 1.4 to 2.3 foot candles is required. And he gives as the minimum for street lighting .09 foot candle.

Professor Morton gives as the intensity of illumination at the back of a room, 20 feet from window, with buildings opposite, from 1¾ to 2¼ foot candles. The range for daylight, he states, will be very great, but the figures given are sufficient for easy reading.

By reference to the table just given we see that if we could obtain from artificial light sources a uniform intensity of illumination equal to the reduced mean intensity even of the 25-candle power lights 100 feet apart, we could have our streets illuminated sufficiently for reading. With the true mean, we should be flooded with light.

Of course, in practice, the lights would be placed above the plane of the surface to be illuminated, and this would tend to make the intensity of illumination more uniform; but I purposely selected this case as showing the full effect of the law of distances.

In this connection Professor Anthony's paper, "The Subdivision and Distribution of Artificial Sources of Illumination," and the discussion thereon, can be read with profit.

Referring to the lighting of villages and suburban places by arc lights, Professor Anthony says:

"A little spot 50 or 100 feet in diameter under each lamp is brilliantly lighted, while the more distant points are in darkness, all the more profound from the loss of sensitiveness of the eye when in the strong light."

Mr. Upton, in course of the discussion, says of the illumination of a building at the Louisville Exposition:

"The result was he (Mr. Stieringer) was able to illuminate a large exhibition building there, so that it looked brilliantly lighted, with a very low grade of absolute illuminating, because there was *no one spot which your eye looked at which made the rest look dark.*"

In all this we are reminded that a weaker light source, more efficiently distributed, and reflected with a view to uniform distribution over the plane of the surface to be illuminated, and in connection with more efficient diffusing surfaces, may give a final result much superior to that obtained from a stronger light-source improperly applied. This difference in favor of the weaker light is sometimes found as the result of accident. This should not be noted as an argument that the photometrically weaker light-source is in practice the stronger, but rather we should take the lesson that the stronger light might be made to give proportionately better results.

In our crude observations we often deceive ourselves by crediting one of the light-sources compared with too great a candle power. With many the tendency seems to be to at once doubt the accuracy of the photometer and everything connected with it. The photometer and its governing laws are not to blame if it is used improperly and partial statements accepted as if they were complete.

See how this applies to the arc light with its so-called 1,000 and 2,000-candle power.

Professor Anthony says there is no 450-watt lamp in use which will give 2,000 candles *in the direction of greatest intensity*, or which will give 500 candles when surrounded by a plain globe and measured for general illumination. On good 450-watt long arc lamps he never obtained but one measurement out of thousands made as high as 2,000 candles.

Mr. Pike, in the discussion of Professor Anthony's paper, stated that "1,200-candle" power lamps in every case ran below 450-candle power when measured spherically.

Apart from the error introduced into our estimates by crediting too high a candle power to the arc, the variations in intensity with the direction is a most disturbing element in our rough calculations for the reasons already referred to.

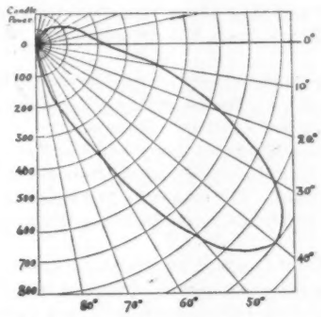


Fig. 3.—Variation in the Intensity of an Arc Light (Continuous Current) with the Inclination. Result of all Photometric Measurements made at Antwerp Exposition.

Fig. 3 shows the variation in the intensity of illumination from an arc lamp with the inclination, and is taken from the work of Professor Palaz. The diagram gives the result of all the photometric measurements made on continuous current lamps at the Antwerp Exposition. But the intensity of illumination also varies with the azimuth; that is, in any given plane, as we move around the lamp with it as a center, its illuminating intensity will vary.

Hence, to correctly state the value of an arc lamp we must state it in mean spherical intensity.

If we do not desire to illuminate above the lamp plane, the efficiency can be increased by a proper system of reflectors; but the light, as a source, should be considered with regard to its mean spherical intensity.

The actual spherical distribution can be made to more uniformly conform to the mean spherical distribution by the simple addition of a translucent globe. Professor Palaz shows that while 15 to 60 per cent. of the total light may be so absorbed, the distribution is quite changed.

He says: "The opalescent globe which surrounds the arc does not absorb the light uniformly; the luminous intensity of the parts of the globe which correspond to the maximum intensity is sensibly decreased, while that part which corresponds to the minimum is increased. The globe itself becomes luminous and plays the part of a radiant."

Incandescent electric lights and flat-flame gas burners also give considerable differences in spherical intensity, and Argand burners give different intensities for different angles of inclination.

All these lights when inclosed in translucent globes also give a more uniform spherical distribution.

Great stress is often laid upon the fact that a light, when inclosed in a translucent globe, gives a better result, and especially has a "greater diffusive power." Part of the explanation of this effect has already been attempted, and in this modification in the variations of intensity is found a further explanation.

In my paper of '87, I detailed graphically and by tables the results of a long series of experiments on flat-flame burners, the candle power being taken horizontally for each degree between 0° (the edge of the flame) and 90° (the flat of the flame), and for many different qualities of water gas, the variations being made by mixing carbureted and uncarbureted water gas in varying proportions. The most general practice at that time was to take the mean between the maximum (flat) reading and the minimum (edge) reading as the candle power.

By the diagram showing my results was obtained the angle at which the burner would have to be placed to give a candle power equal to the mean of the maximum and minimum. This angle was found to vary, for the different gases, between 1.5° and 10.25°, and the mean of all the readings was 4.68°.

A fairer method in each case would be to take the mean of all readings instead of the mean of the maximum and minimum. The diagram could be used for this purpose.

In connection with these experiments it is to be noted that the difference in readings between the flat and edge as a rule increased with the increase of candle power of the gas, indicating a falling off in the transparency of the flames with the increase in density.

Mineral oil flames show still more strongly this absorption of light during passage through its own flame, and this becomes very evident when testing large burners made up of a number of concentric rings.

Professor Mayer, in his paper "On the Illuminating Power of Flat Petroleum Flames in Various Azimuths," gives the results of his experiments with two types of petroleum burners, one the Hitchcock chimney-less, air-blast lamp, and the other the ordinary lamp with chimney. With the Hitchcock lamp, the candle power from the edge of the flame was found to be 37 per cent. less than that from the flat; and with the ordinary lamp, the difference was found to be 38 per cent.

As bearing upon the question of the modification of spherical intensity by the use of globes, etc., Professor Mayer found that even the use of a clear glass chimney had an effect. He says:

"The flame of the Hitchcock lamp and the flame of the ordinary petroleum lamp with chimney increases in candle power with the azimuth in different rates. The reason for this is that the glass chimney acts as a reflector and tends to equalize the illumination in different azimuths."

Mr. Dibdin, in his "Practical Photometry," goes quite fully into the difference between the candle power of burners as determined horizontally and spherically, and shows his results by a number of diagrams.

Another source of error in our "practical" comparisons is in failing to keep in mind the (perhaps necessarily) arbitrary conditions imposed as to the standard burners to be employed in determining "candle power."

If the standard burner gives a result not in accord with the burners under observation, then to that extent are we astray in our premises. This difference is sometimes in favor of, and sometimes against, the gas as ordinarily consumed.

Sheard's and Hinman's experiments show that a certain per cent. of CO_2 will reduce the illuminating power of the gas as consumed in a flat-flamed burner to a greater extent than if burned in an argand burner. Here, then, two gases of equal "candle power" would give unequal illuminating effects if burned commercially in flat-flames.

This lack of agreement is not due to any fault in the photometer, but to our arbitrary selection of a standard burner. The effect of CO_2 is less depreciating in the case of a higher power gas, and this difference between the "candle power" and the practical result would be eliminated, as the higher candle power gases (in America, at least), are tested by the same burner most generally used by the consumer, viz., the flat-flame.

Photometrical Work.—Now let us consider briefly the photometer and its manipulation. Photometry has been developed as the result of the conscientious, independent labors through many years of many scientists and engineers. Photometers have been devised upon different principles in optics, including diaphragmation, dispersion and the phenomena of absorption, polarization and compensation, etc. Chemical photometry has also received attention.

But the photometers which we are most interested in are those based upon the direct comparison of two illuminated surfaces, as the Rumford, the Bouguer, the Foucault, the Bunsen and the Arnoux. The first four depend upon the law of distances and the last upon the cosine law.

The Bunsen is chiefly employed in America, Great Britain and Germany, and the Foucault in France.

The Rumford is by us generally regarded as obsolete, though such a high authority as Captain Abney prefers it above all others. On the other hand, Dibdin pronounces against it.

Inferential photometry has been the subject of much investigation, and the jet photometer and the illuminating power meter have been largely used. Many schemes have been suggested for calculating the candle power of a gas from its contained illuminants or from the composition of the products of combustion.

Investigations as to the cause of luminosity in gas flames, and especially the recent investigations of Professor Lewes, William Young, Irwin and others, indicate that inferential methods cannot safely be employed for the *general* comparison of the illuminating power of gases; and for long we have known that the character of the diluent gases modified the readings of inferential photometers. But for the comparing of gases made from the same class of materials and by the same apparatus and methods, they can be made to serve a useful purpose.

In the so-called Bunsen photometer we find an instrument which is practically accurate, and as simple as any such laboratory instrument can well be.

The instrument gets its name from the grease spot disc. Bunsen's photometer was quite different from the one now employed. Mr. Alfred King, of Liverpool, took the Bunsen disc and built around it the photometer much as we use it to-day. He used the open photometer in a dark room, the bar 100 inches, the two lights fixed, and the disc set up without sight-box and without mirrors, but reversible with regard to the lights.

This photometer since then has been modified in many ways. A wide departure was made in the Evans. As originally made, it was not adapted for general testing. In some of its present, forms it is no doubt a reliable instrument, and especially so when the lights are fixed and the ventilation so better provided for, and the sight-box properly screened. Dr. Letheby introduced the sight-box as now generally used. This is an improvement in that the mirrors enable us to see the two sides of the disc simultaneously; but it fails to provide, as did King's arrangement, for the reversal of the disc with regard to the lights, to compensate for differences in its two sides.

The elaborate and able report of the Dutch Photometry Committee makes a strong point of the necessity for this reversal. It goes farther and says the readings should be made one-half from one side of the table and the other half from the other side, this to compensate for differences in the eyes of the observer. The report condemns the English practice of correcting for candle and gas consumption by the proportional rule; and also the employment of two candles instead of one, and especially if the distance between the disc and the candles is allowed to vary.

Dibdin urges the importance of the reversal of the disc, and has improved the sight-box by pivotting at the back, the frame containing disc and mirrors, so that it can be revolved around a horizontal axis. He designs to thus compensate also for any differences in the mirrors.

As far as I am aware, Tufts, of Boston, is the only photometer maker in this country who provides for this compensative method. This is possibly a refinement, but it behooves us to adopt all such refinements if they do not lead to complication of apparatus and methods.

The selection of a disc is all-important. No matter what form is used, it should be tested by the reversal method and, unless the readings are then alike, it should be rejected. A disc should be rejected wherein the spot entirely disappears.

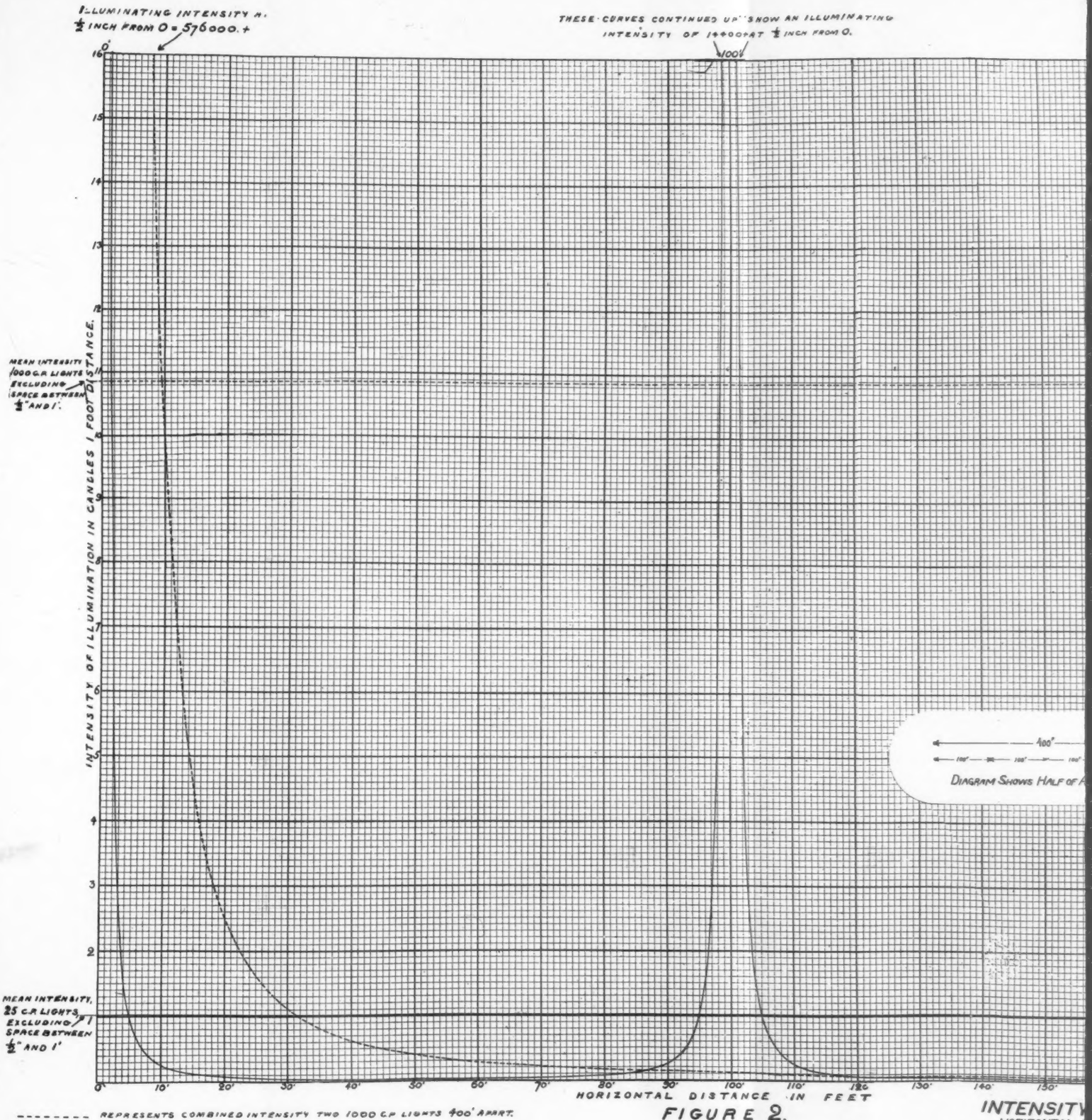
After a good disc has been selected we must remember it is liable to change, and especially under constant exposure to light and a dirty atmosphere. A disc that becomes soiled or marred should be abondoned.

In my opinion the Leeson star disc is a decided improvement over the regular Bunsen disc, and especially in connection with difference in the color of the opposed lights. Dibdin strongly endorses the star disc, but holds that as first made it was not satisfactory on account of "buckling." He improved it by fastening the three pieces of paper together with thin starch water, under pressure.

Captain Abney and Professor Lewes endorse the Dibdin-Leeson disc for its reliability even when this difference in color exists. Captain Abney suggests as an additional safeguard against error in disc reading, the oscillation of the disc between points too dark and too bright, gradually reducing the length of swing.

I am not aware that the Dibdin-Leeson discs have been regularly introduced into this country, but the American Meter Company makes a star disc which seems to give satisfactory results. The three papers are kept smooth and held firmly together by two pieces of glass which are held in place in the disc frame by tight metal rings. As far as possible, to prevent error from unequal absorption, the glass is carefully selected and the two pieces are cut from the same sheet. If this disc was used in a reversal sight-box, any possible difference would be discovered or compensated for. The enclosing of the disc in glass should help to prevent deterioration and change.

Referring again to the other points noted as made by the Dutch Committee, I believe the majority of American and English experts agree that under certain restrictions the use of two candles tends to decrease rather than increase the total error. The obliquity of rays does not sensibly affect the reading if the disc is not closer than 12


ILLUMINATING INTENSITY AT ½ INCH FROM O = 576000.+
THESE CURVES CONTINUED UP SHOW AN ILLUMINATING INTENSITY OF 1440000+ AT ½ INCH FROM O.
100'
MEAN INTENSITY 1000 C.P. LIGHTS EXCLUDING SPACE BETWEEN ½" AND 1'.
MEAN INTENSITY, 25 C.P. LIGHTS EXCLUDING SPACE BETWEEN ½" AND 1'
INTENSITY OF ILLUMINATION IN CANDLES I FOOT DISTANCE.
0 10' 20' 30' 40' 50' 60' 70' 80' 90' 100' 110' 120' 130' 140' 150'
HORIZONTAL DISTANCE IN FEET
400'
DIAGRAM SHOWS HALF OF A

-------- REPRESENTS COMBINED INTENSITY TWO 1000 C.P. LIGHTS 400' APART.

———— " " " " 25 " " 100' "

FIGURE 2.

INTENSITY
HORIZONTAL
The Light Sources Spherical

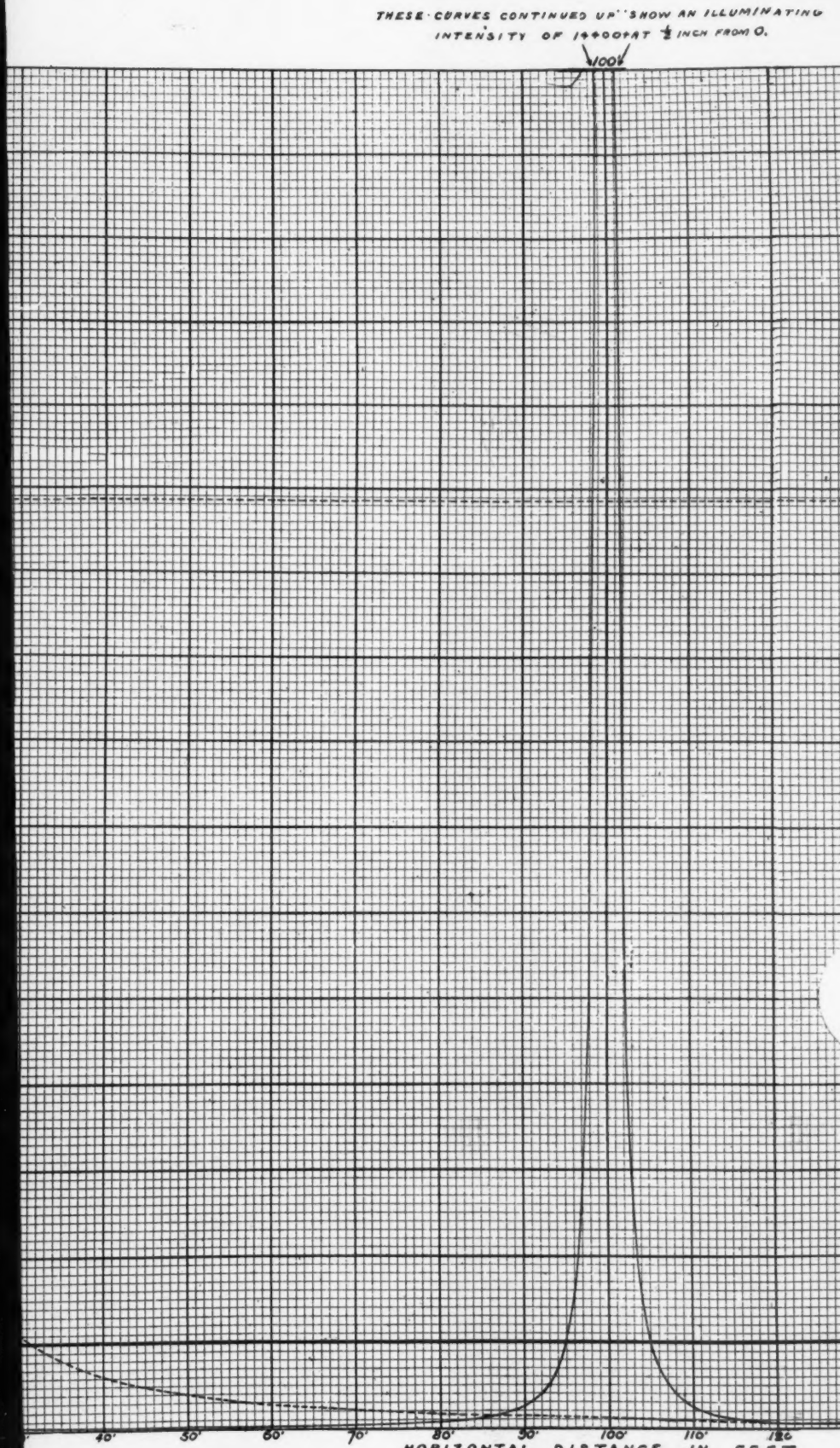
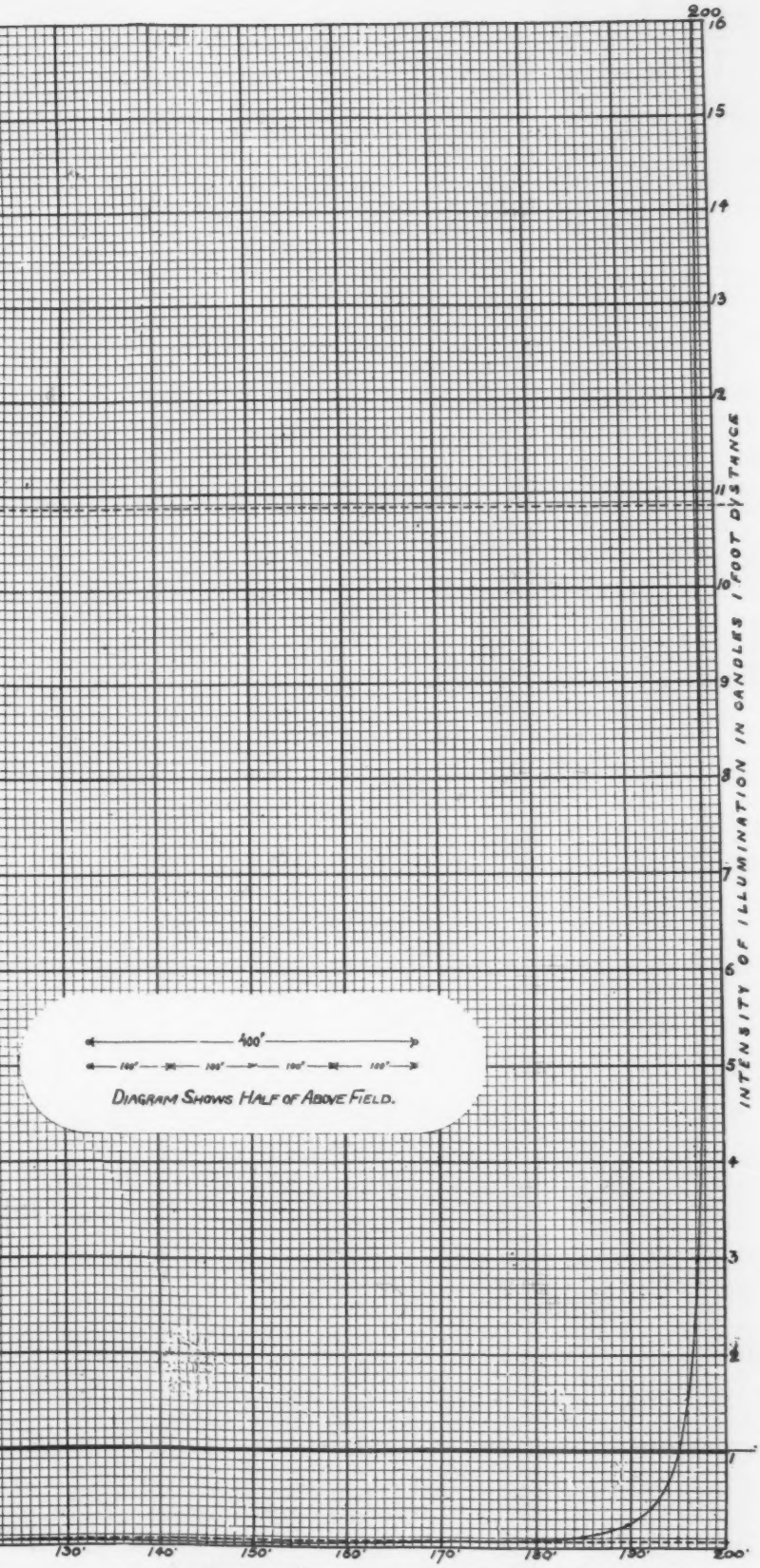

THESE CURVES CONTINUED UP SHOW AN ILLUMINATING INTENSITY OF 14400 FT AT ½ INCH FROM O.
1000
40'
50'
60'
70'
80'
90'
100'
110'
120
HORIZONTAL DISTANCE IN FEET
TY TWO 1000 C.P LIGHTS 400' APART.
" 25 " " 100' "

FIGURE 2.



INTENSITY OF ILLUMINATION;

HORIZONTAL RAYS UPON VERTICAL SURFACES.

The Light Sources Spherical and 1 inch Diameter; 1000 C.P. & 25 C.P. Respectively.

inches, and a reference to the table to follow shows that up to 30-candle power gas, this distance is more thon 12-inches, even with the 60-inch bar.

But these and other sources of error connected with the use of the much abused candle standard can, apparently, now be eliminated by the adoption of Dibdin's 10-candle pentane Argand air-gas standard. This standard (as a development from the Harcourt 1-candle pentane standard) has been under careful examination by English scientists and practical photometrists for some years, and the Photometric Standard Committee in its recent report to the (English) Board of Trade recommends its adoption for the testing of London gas. The strength of the committee and the record of its work will, no doubt, secure the adoption of its recommendations. It seems to be demonstrated that this standard gives uniform results even with considerable variations in temperature, pressure, height of flames and the composition of the pentane mixture.

Dibdin states that the height of the flame may vary 1½ inches without sensibly affecting the amount of light reaching the disc therefrom.

It is true that there are those in England who do not indorse the committee's recommendation.

Mr. Williams has recently objected to this standard on the ground that it refers back to the candle as its unit, and, therefore, its use is simply a roundabout way of using candles. The reasoning does not appear to be sound, for if the pentane lamp gives constantly uniform results without too great complexity we make a decided gain. Further, the unit of the proposed standard is the mean obtained from a great number of readings by most competent photometrists, and therefore is, in that regard, far more reliable than any isolated observation.

Another decided advantage possessed by the pentane standard is that it is of a relatively high candle power. Referring to the table to follow, "Comparison between 60-inch and 100-inch bars," we see that with this standard the intensity of illumination of the disc more nearly corresponds to moderate degrees of diffused daylight, and the eye is capable of making, under these circumstances, finer distinctions than if the intensity of illuminatio n was either excessively low or high.

With regard to the comparison between bars of different lengths, the statement is sometimes made that the change from King's 100-inch bar to Letheby's 60-inch bar was an improvement. I confess I have not in the past agreed with this statement. In connection with this paper I have prepared a table showing the illuminating intensities upon the disc with 60-inch and 100-inch bars, for 16, 20, 25 and 30-candle power gases, and for 1, 2 and 10-candle standards.

Comparison between 60-Inch and 100-Inch Bars.

D. Distance of disc from light standard, in inches.

I. Intensity of illumination of disc in terms of 1 candle at 1 foot.

Candle Power of Gas.	60-Inch Bar. Standard.						100-Inch Bar. Standard.					
	1 Candle.		2 Candles.		10 Candles.		1 Candle.		2 Candles.		10 Candles.	
	D.	I.	D.	I.	D.	I.	D.	I.	D.	I.	D.	I.
16	12.00	1.00	15.66	1.17	26.49	2.05	20.00	.36	26.13	.42	44.17	.73
20.	13.96	1.20	14.42	1.38	24.84	2.33	18.27	.43	24.04	.49	41.41	.84
25.....	10.00	1.44	13.23	1.64	23.24	2.66	16.67	.52	22.04	.58	38.74	.96
30.....	9.26	1.67	12.32	1.90	21.96	2.98	15.44	.61	20.52	.68	36.60	1.08

An examination of the table confirms the claim to improvement. On the 100-inch bar with the 1-candle standard, the intensity is only from .36 to .61 foot candle; and even with the 10-candle standard the intensity only reaches 1.08 foot candles. The 60 inch bar is, therefore, to be proferred for the ordinary gas testing; for the testing of high power light-sources a larger bar should be employed. If we have our dark room of sufficient length, and we are not constantly making such tests, they can be conveniently enough provided for by having a full length portable table, the calculations to be made from tape measurements.

But in this connection it is well to bear in mind that with new forms of light-sources, and especially with high candle power lamps, the candle power should be taken spherically, and for this a radial photometer is required.

For the comparison of the illuminating power of gases a horizontal test is sufficient, because the character of the gas does not change the result, except in a minor degree by reason of the flames of higher candle power gases having a greater absorptive power for their own light than lower candle power gases, as already referred to.

With the flat-flame burner, this can be provided for by making the test with the burner at such an angle as will give the mean angular candle power.

For spherical photometry Mr. Dibdin has improved the Hartley "Universal" photometer by arranging the disc so that it can be readily adjusted to receive the rays from the standard and the light-source under examination at the same angle of incidence. This at once eliminates the necessity for correction on account of the cosine law, and also the departure from that law by reason of variation of absorption and reflection with the angle.

This photometer is fully described in Dibdin's "Practical Photometry."

Upon the important questions of corrections for variations in the gas and candle consumptions, there exists considerable difference of opinion. The English method, which we follow, provides for correction by the rules of proportion. Many English experts have long held that a method more nearly like the French (namely, the measuring of the quantity of gas required to give a standard candle power) should be employed. The report of the Photometric Standard Committee recommends that the present rule "be rescinded so as to allow the Gas Referees to sanction a mode of testing in which the gas shall be burned from the standard 'London' Argand burner at whatever rate is found requisite, in order that it may give a light equal to that of the prescribed number of candles in which the illuminating value of the gas shall be calculated as being inversely as the rate at which such gas had to be burned during the testing, so as to give this amount of light."

This may on the average be a fairer rule than the present one. It more especially applies to the testing under English conditions, when there is in each case a prescribed candle power to be maintained.

But any such rule must be arbitrary, and its discussion is not necessarily involved in the question of measurement of *light*. If we could in the case of each gas, fix such conditions as would give the nearest possible measure of the *absolute* illuminating value of the gas, we should have made a great step and be in a position to avoid many of the difficulties involved in the question of difference between "candle power" and illuminating effect.

But I cannot see that we can ever hope to make a direct comparison between the *absolute* illuminating value of gases, for how can we ever say that any given burner accords to any two gases of different composition the same percentage of illuminating efficiency? At the best, our success in this direction can be only approximate.

But it is to be remembered that the ability of the photometer to accurately compare the illuminating value of any two light-sources, or of any two gases burned under prescribed conditions, is not involved in this last question.

As a matter of commercial fairness, it would seem as if the comparison should be made with the gases burned in each case in a way which the consumers could easily, simply and economically employ, and would, under those conditions, give each gas so burned the greatest possible efficiency. This would seem to point to the general use for testing, of high grade, though cheap, flat-flame burners.

I have thus endeavored to touch upon some of the more important features involved in accurate photometry.

Of course, we must always remember that the photometer is an instrument to be used as prescribed *and with all limiting conditions well in mind.*

Accumulation of dust, etc., may cause sensible error.

The room should be maintained, as far as possible, at the normal temperature.

The various parts of the instrument should be re-adjusted and re-standardized from time to time. It should not be taken for granted that the two lights are exactly 60 inches or 100 inches apart, and that the center of the bar is exactly midway between the lights; that the meter is accurate or that the candle balance is sufficiently sensitive. I have seen numbers of balances in American photometer rooms which were attractive enough in appearance, but which were better adapted for use in a grocery than in a laboratory.

The ventilation of the photometer and the room should be well cared for. An accumulation of CO_2 from the products of combustion and an increase in temperature are prolific sources of error. The instant a disc becomes discolored or marred, it should be replaced.

To the younger members I may, perhaps, venture to suggest that it is necessary to study photometry to be sure of results. Do not be willing to *blindly* follow the methods prevailing at your station.

In the Appendix, Exhibit A, the index will be found to contain references to much that is not involved in ordinary gas photometry, but there is not an engineer here present who can afford to be without "Industrial Photometry," by Professor Palaz, Hartley's Gas Analysts' Manual, and "Practical Photometry" by Dibdin. The former is pre-

pared for the guidance of electric light engineers, and is more especially devoted to mathematical discussions of the principles of photometry and illumination, but it is a mine of information for the gas engineer. Hartley's Manual is well known amongst us, and Dibdin's work is exactly what its title implies.

In addition, in the index will be found the titles of many papers full of valuable suggestions to the practical student. I may specially mention Professor Lewes' and William Young's papers on the luminosity of gas flames, Mr. Sheard's paper on effect of CO_2 and his discussion of Mr. Newbigging's paper, Professor Anthony's paper already referred to, Professor Mayer's account of Sector disc experiments, Captain Abney's lectures and Mr. Sugg's paper on photometry.

As gas engineers engaged in the practical, every day work of our profession, we cannot expect to do much in the way of original investigation in the science of optics, but we can keep informed as to the progress in practical photometry, and possibly we may assist the men of science in putting the results of their patient labors into more practical shape.

Before concluding, I wish to raise my voice in earnest protest against too ready condemnation of the photometer. Before a recent meeting of a sister association a remark was made to the effect that the photometer could be made to give any reading to suit the prejudices of the observer. Is it not at once to be understood that in any laboratory test, the statement of the result is absolutely dependent upon not only the accuracy of the instrument and the skill of the experimenter, but upon his honesty? Why should we expect the photometer to give accurate results irrespective of the observer's wishes?

Commercially reliable results can be obtained, and are constantly being obtained, with the bar photometer, and if they are not so obtained the one charged with the making of the tests should be held responsible. Of course, where results far outside of the beaten track are obtained it is reasonable that we should ask if these abnormal results were not obtained while some of the sources of error were out of mind. In such extreme cases no honest investigator would object to the request for confirmation.

No doubt lack of uniformity in the instruments and in the manipulative methods employed, add to our difficulties, but this can be improved, not by condemning the photometer as worthless, but by recognizing its intrinsic worth and then co-operating to make its statements more uniformly comparable.

Further still, after we get our statements from the photometer let us bear in mind that it still rests with us to properly interpret those statements.

The prime importance of sending out a uniform quality of gas will be readily admitted by all. Without the photometer how shall this be insured?

In conclusion, I maintain, that "candle power" is a true measure of illuminating power *under the conditions prescribed for the test.*

That the photometer can be relied upon with confidence to correctly measure the illuminating power of a *light-source.*

That the total illumination and the intensity of illumination must of necessity vary with the subdivision and distribution of our light-source, and with the nature of the surrounding surfaces.

That a measurement of the spherical "candle power" of the light-source and a determination of its color composition will, as far as possible, enable us to estimate the light effect obtainable under varying conditions.

That the actual measurement of the total illumination of an inclosed space and of the different degrees of intensity of illumination, is well-nigh impossible, and our failure in this direction is no criticism of the photometer or of the principles upon which it operates.

That the intensity of illumination, either of an open or of an inclosed space, cannot be made uniform by the employment of any artificial light-source, but our aim should be to modify the effect of the law of distances and the spherical distribution from the light-source, so that, as far as possible, the illumination should be distributed uniformly where required.

That it should be our aim, as far as possible, to shield the eye from the direct light rays, and so give the eye the fullest possible opportunity to appreciate the illumination afforded.

APPENDIX.

EXHIBIT A.—*Index of Standard Works and Extracts from Recent Gas Periodicals on Photometry and Illumination, Referred to in Foregoing Paper.*

NOTE.—The books and papers are first shown in alphabetical order; the authors are then shown in alphabetical order, their writings being referred to by number.

NOTE.—J. of G. L., (London) Journal of Gas Lighting; G. W., The (London) Gas World; P. A., (New York) Progressive Age; A. G. L. J., (New York) AMERICAN GAS LIGHT JOURNAL.

1. "Acetylene and the Part It Plays in the Luminosity of Flame." Prof. Vivian B. Lewes. Lecture before 32d Annual Meeting Incorporated Gas Inst. G. W., June 15, 1895.
2. "Bar Photometer, The." Editorial. P. A., Jan 16, 1893.
3. "Candles—Rules Recently Promulgated by the Gas Referees." P. A., Jan. 15, 1894, "London Gas Testing," and also copied in full in this Appendix.
4. "Candle Power and Illumination." C. F. Prichard. Paper read before the 17th annual meeting N. E. Ass'n Gas Eng'rs, 1887. A. G. L. J., March 2, 1877. Discussion (with paper by Taber—"Units of Photometry") March 2, 1887.
5. "Candle Power and Illumination, Suggestions Upon." A. E. Boardman. Paper read before 14th annual meeting Am. Gas Lt. Ass'n, 1887. A. G. L. J., Jan. 3, 1887.
6. "Carbonic Acid Upon Illg. Power Coal Gas, The Effect of." By Jno. T. Sheard, F. C. S. Communicated to J. of G. L. A. G. L. J., Oct. 17, 1887.
7. "Carbonic Acid on Illuminating Power of Coal Gas, Effect of." C. W. Hinman, Mass. Gas Inspector. A. G. L. J., Nov. 2, 1887.
8. "Cathode Rays." Lennard in Wiedemann's Annalen; Summary J. of G. L., April 3, 1894.
9. "Chemical Constitution of Gas Enrichers, and its Relation to their Enriching Value, The." Wilfred Irwin, F.C.S. Paper before Manchester Section, Society of Chemical Industry. G. W. July 20, 1895.
10. "Dutch Gas Association's Report on Photometry, The." Translation with illustrations. G. W., Sept. 8, 22, 29; Oct. 6, 13, 1894, or, P. A., Oct. 1, 15; Nov. 1, 15, 1894.
11. Summary and comments. J. of G. L., Dec. 18, 25, 1894.
12. Letter of comment. Lewis T. Wright, G. W., Oct. 20, 1894.
13. "Dazzling Effect of Flashes of Light, The." Shelford Bidwell. Communication to Royal Society—Summary J. of G. L., Oct. 9, 1894.
14. "Dibdin's 10-Candle Pentane Argand Air-Gas Standard." Illustrated description of the apparatus—being part of appendix of Standard Committee's Report. J. of G. L., May 14, 1895. Also copied in full in this appendix.
15. "Diffused Reflection, Photometry of." By E. Lommel. Abstract from Wiedemann's Annalen—A. G. L. J., Nov. 5, 1894.
16. "Diffusion of Light from Dull Surfaces." Contributed to Wiedemann's Annalen by Christian Wiener. Summary—J. of G. L., Nov. 13, 1894.
17. "Electric Arc as a Standard of Light, Unreliability of." A. P. Trotter. Comments on paper read before Royal Society. J. of G. L., Aug. 28, 1894.
18. "Flame Dimensions a Test of the Luminosity of Candles." P. Glan. Communicated to Wiedemann's Annalen. Summary—J. of G. L., March 20, 1894. "Electrician's" Comments—J. of G. L., April 3, 1894.
19. "Gas Analysts' Manual, The." F. W. Hartley, A.I.C.E., etc. Published by E. & F. N. Spon.
20. "Illumination." By W. Ivison Macadam, F.R.S.E., F.I.C., F.C.S., etc. Paper before 32d annual meeting, Incorporated Gas Institute. G. W., June 15, 1895.
21. "Illumination vs. Candle Power." Paper by Alex. C. Humphreys, M.E., before 15th annual meeting Amer. G. L. Ass'n, 1887. A. G. L. J., Nov. 2, 1887. Discussion (with paper by E. C. Jones). A. G. L. J., Nov. 2, 1887.
22. "Illuminating Power and Illuminating Effect." Thomas Newbigging. Paper before (English) Incorporated Gas Institute, 1894. J. of G. L., June 26, 1894. Discussion, J. of G. L., July 3, 1894.
23. Letter by Charles Hunt. J. of G. L., July 3, 1894.
24. Reply by Thomas Newbigging. J. of G. L., July 10, 1894.
25. Reply by Charles Hunt. J. of G. L., July 17, 1894.
26. Letter by "A Modest Gas Consumer." J. of G. L., Nov. 13, 1894.
27. Letter and Inclosure. Thomas Newbigging. J. of G. L., Sept. 4, 1894.
28. Editorial Comments on Above. J. of G. L., Sept. 4, 1894.
29. Letter, "Provincial Manager." J. of G. L., Aug. 7, 1894.
30. Letter, G. E. Stevenson. G. W., Nov. 10, 1894.
31. Comments by J. P. Gill. A. G. L. J., Aug. 13, 1894.
32. Letter in reply to Mr. Gill, Thomas Newbigging. G. W., Nov. 3, 1894.
33. Letter in reply by Mr. Gill. G. W., Dec. 22, 1894.
34. Letter in reply by Mr. Newbigging. G. W., Dec. 22, 1894.
35. Discussion—Communicated Articles, Jno. T. Sheard. J. G. L., Sept. 11, 18, 1894.
36. "Incandescent Gas Lighting." Dr. Wedding. Summary of Address to the Ass'n German Engrs. G. W., Aug. 10, 1895.
37. "Industrial Photometry, A Treatise on." Prof. A. Palaz, Sc. D.

Translated by Prof. Geo. W. Patterson, Jr., M. A., B. S., and M. R. Patterson, B. A. Published by D. Van Nostrand Co., New York; Sampson Low, Marston & Co., Ltd., London.

38. "Intensity of Light and Visual Perception, The Relation of." By Edward C. Jones. Before the 15th Annual Meeting Amer. G. L. Ass'n, 1887. A. G. L. J., Nov. 2, 1887. Discussion (with paper by A. C. Humpreys.) A. G. L. J., Nov. 2, 1887.
39. "Lighting Power of White and Yellow Flames, The." Discussion at the Polytechnic Society of Berlin. G. W., Jan. 5, 1895.
40. "London Gas Testing." Editorial. P. A., Jan. 15, 1894.
41. "Luminosity in the Flames of Hydro-Carbon Gases, The." By Prof. Vivian B. Lewes. Communicated to the Royal Society. A. G. L. J., April 22, 1895.
42. "New Photometrical Method, A." J. B. Spurge. Comments on Paper Read Before Physical Society. J. of G. L., Feb. 27, 1894.
43. "New Platinum Standard of Light." (See also Nos. 58 and 70.) O. Lummer and F. Kurlbaum. J. of G. L., Dec. 11, 1894.
44. "New Standard of Light, The." W. J. Dibdin, F. I. C., F. C. S. Report of Lecture. J. of G. L., Nov. 6, 1894.
45. "Notes on the Chemical Constitution of Illuminating Gas in Relation to its Illuminating Value, and on Some of the Physico-Chemical Conditions Which Influence the Luminosity of Gas Flames." W. Young. Paper read before the 34th Annual Meeting North British Association of Gas Managers. J. of G. L., July 30, 1895. Discussion. J. of G. L., July 30, 1895.
46. "Photo-Electric Phenomena." J. Elster and H. Geitel. Letter to "Nature." Summary—J. of G. L., Oct. 9, 1894.
46½. "Illuminating Power of Flat Petroleum Flames in Various Azimuths, On the." By Prof. Alfred M. Mayer, *American Journal of Science*, January, 1891.
47. "Photometrical Nomenclature, A Systematized." André Blondel in La Lumière Electrique. Summarized in J. of G. L., Dec. 18, 1894.
48. "Photometrical Suggestions." J. M. Barr and C. E. S. Phillips. Paper on "Brightness of Light," before (English) Institution Electrical Engrs. J. of G. L., March 27, 1894.
49. "Photometrical Standard Committee, The Work of the." Prof. Vivian B. Lewes. Paper read before the Incorporated Inst. of Gas Engrs., 1895. J. of G. L., May 14, 1895.
50. Report of the Committee. Appended to above paper, and also copied in full in this appendix. J. of G. L., May 14, 1895. Discussion of Paper. J. of G. L., May 21, 1895. (See "Dibdin's Ten-Candle Pentane Argand Air-Gas Standard.")
51. Letter by E. Williams, F. C. S. J. of G. L., Sept 10, 1895.
52. "Photometry." Editorial. P. A., Sept. 15, 1894.
53. "Photometry." Series of Lectures (3) delivered by Capt. W. de W. Abney, F. R. S., before British Society of Arts. A. G. L. J., Aug. 27 and Sept. 3 and 10, 1894. Summary and Comments, first lecture. G. W., April 7, 1894.
54. "Photometry as Applied to the Verification of the Illuminating Power of Gas Supplied to Towns." By Mr. Wm. Sugg. Paper before the 32d annual meeting Incorporated Gas Institute. G.W., June 15, 1895.
55. "Photometry of Beacon Lamps." Du Richie Preller. Letter to *Engineering*. Summary—J. of G. L,, April 10, 1894.
56. "Pupilometry and Photometry." Charles Henry. Summary—J. of G. L., Sept. 4, 1894.
57. "Practical Photometry." W. J. Dibdin, F.I.C.,F.C.S., etc. Published by Walter King, London; D. Van Nostrand Co., New York.
58. "Radiometry and Photometry." (Also see Nos. 43 and 70.) O. Lummer and F. Kurlbaum. Synopsis from Wiedemann's Annalen. J. of G. L., Dec. 25, 1894.
59. "Rotating Sector Disc Photometry." Ervin S. Ferry. Summary—J. of G. L., June 19, 1894.
60. "Rule of the Inverse Squares, The." B. E. Chollar. Paper read before the 10th annual meeting Western Gas Ass'n. A. G. L. J., July 2, 1887. Discussion. A. G. L. J., July 16, 1887.
61. "Sensitiveness of the Eye." M. Broca. Summary—G. W., Feb. 2, 1895.
62. "Some Experiments in the Photometer Room." By N. W. Gifford. Paper read before N. E. Ass'n. Gas Engrs., 1890. A. G. L. J., March 10, 1890.
63. "Standard Candles." Communicated Article, E. G. Love, Ph.D. A. G. L. J., March 5, 1894, or J. of G. L., March 20, 1894.
64. "Studies of the Phenomena of Simultaneous Contrast Color, and on a Photometer for Measuring the Intensities of Lights of Different Colors." (4 papers.) By Prof. Alfred M. Mayer. P. A., Jan. 15, 1894; Feb. 1 and 15, and March 1, 1894. (From Amer. Journal of Science, July, 1893.)
65. "Subdivision and Distribution of Artificial Sources of Illumination." By Prof. Wm. A. Anthony. Paper read before 11th general meeting of American Inst. Electrical Engrs. P. A., Oct. 15, 1894. Discussion. P. A., Oct. 15, 1894.
66. "Ten-Candle Lamp for Use in Photometry." A. Vernon Harcourt, M.A.,F.R.S. Paper read before Physical Section of British Ass'n. J. of G. L., Aug. 28, 1894.
67. "Testing of Gas, The." Being one (VII.) of a Series of Lectures on the Technology of Coal Gas. By Prof. Vivian B. Lewes, F.I.C., F.C.S. J. of G. L., March 13, 1894.
68. "Ultra-red Rays, The Reason for the Non-Visibility of." Comments on Paper in Wiedemann's Annalen. J. of G. L., Sept. 3, 1895.
69. "Unconsidered Source of Error in Practical Photometry, An." H. L, Greville, F.I.C. Communicated to J. of G. L. A. G. L. J., April 17, 1893.
70. "Unit of Light, The Search for A." (See also Nos. 43 and 58.) O. Lummer and F. Kurlbaum. P. A., Feb. 1, 1895.
71. "Units of Photometry." R. B. Taber. Paper read before 17th annual meeting N. E. Ass'n. Gas Engrs., 1887. A. G. L. J., March 2, 1887. Discussion (with paper by Prichard—"Candle Power and Illumination,") March 2, 1887.
72. "Unobserved Effect of Light, An." F. Elfving. Summary from journal of a Finnish Philosophical Society. J. of G. L., March 27, 1894.
73. "Valuing Illuminating Gas, A New Method of." John T. Sheard, F.C.S. Communicated Article. J. of G. L., Feb. 27, 1894.
74. Letter in reply, P. Aguitton. J. of G. L., March 20, 1894.
75. Letter in reply, John T. Sheard. J. of G. L., March 27, 1894.

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Love, Dr. E. G..... 63
Lummer, O.....43, 58, 70
Macadam, W. Ivison..... 20
Mayer, Prof. A. M.....46½, 64
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Patterson, M. R..... 37
Phillips, C. E. S..... 48
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Taber, R. B..... 71
Trotter, A. P 17
Wedding, Dr..... 36
Wiener, Christian 16
Williams, E..... 51
Wright, Lewis T..... 12
Young, W..... 45

EXHIBIT B.—*Comparative Table of Different Photometric Standards.* By Violle. Quoted from Industrial Photometry, A. Palaz.

	Violle Units.	Carcels.	Star Candles.	German Candles.	English Candles.	Hefner-Alteneck Lamps.
Violle units	1.000	2.08	16.100	16.400	18.50	18.90
Carcels	0.481	1.00	7.750	7.890	8.91	9.08
Star candles	0.062	0.130	1.000	1.020	1.15	1.17
German candles	0.061	0.127	0.984	1.000	1.13	1.15
English candles	0 054	0.112	0.870	0.886	1.00	1.02
Hefner-Alteneck lamps	0.053	0.114	0.853	0.869	0.98	1.00

Dutch Gas Association's Report on Photometry gives the following:

Carcel = 9.631 English candles.
German Candle = 1.1053 English candles.
Hefner-Alteneck = 9.213 " "
Ether-Benzol Standard (as proposed by committee) = 1.48 English candles.

London 16-*Candle gas* corresponds to 17.5 candles by the Berlin burner, and to a consumption of 99.2 litres per hour by the Paris method.

The Paris standard consumption of 105 *litres per hour* corresponds to 14.7 candles by the London, and 16.8 candles by the Berlin burner.

Berlin 16-*Candle gas* corresponds to 13.4 candles with London burner, and to a consumption of 110 litres per hour by the Paris method.

Dibdin gives

Carcel, as determined by Sugg = 9.6 English candles.
" " himself = 9.4 " "

Mean, 9.5

Harcourt's Pentane Air Gas Standard = 1 English candle.

Dibdin's Pentane Argand Air Gas Standard = 10 English candles.

Comparisons between the pentane standards and the other standards as given by Violle can be made by reference to the foregoing table, reading the columns for English candles for the Harcourt standard and for the Dibdin standard reading the same columns, moving the decimal point one place to the right in the horizontal line, and one place to the left in the vertical column.

EXHIBIT C.—*Candles.*

Rules Recently Promulgated by the Gas Referees in Connection with the Testing of London Gas.

1. All candles to be used in the testing places shall be made with the materials hereinafter prescribed, and shall, when made, be examined and certified by the Gas Referees.

2. The wicks shall be made of three strands of cotton plaited together, each strand consisting of 18 threads. The strands shall be plaited with such closeness when the wick is laid upon a rule, and extended by a pull just sufficient to straighten it, the number of plaits in 4 inches shall not exceed 34, nor fall short of 32. Each wick shall be of suitable length, and looped ready for fixing in the mold. After having been bleached in the usual manner and thoroughly washed (see appendix) the wicks shall be steeped in a liquid made by dissolving one ounce of crystallized boracic acid in a gallon of distilled water, and adding two ounces of liquid ammonia. They are then to be gently wrung or pressed till most of the liquid has been removed, and dried at a moderate heat. Twelve inches of wick thus made and treated shall weigh not more than 6.5 nor less than 6 grains. The weight of the ash remaining after the burning of ten wicks which have not been steeped in boracic acid, or from which the boracic acid has been washed out, shall be not more than 0.025 grain. Wicks made in accordance with this prescription shall be sent to the office of the Gas Referees, by whom they will be examined and certified. The wicks so certified are to be used by the candle maker in the condition in which they are returned to him.

3. The spermaceti of which the candles are made shall be genuine spermaceti, extracted in the United Kingdom from crude sperm oil, the product of the sperm whale, (*Physeter Macrocephalus.*) It shall be so refined as to have a melting point lying between 112° and 115° Fahr. An account of the method by which the melting point of the spermaceti is to be determined is given in the appendix. Since candles made with spermaceti alone are brittle, and the cup, which they form in burning, has an uneven edge, it is necessary to add a small proportion of beeswax or paraffin to remedy these defects. We therefore prescribe that the best air bleached beeswax, melting at or about 144° Fahr., and no other material, shall be used for this purpose, and that the proportion of beeswax to spermaceti shall be not less than 3 per cent., nor more than 4½ per cent.

4. The candles made with the materials above prescribed shall each weigh, as nearly as may be, one-sixth of a pound, and will be found to answer to the following test: Immerse a candle, taper end downward, in water of 60° F., with a brass weight of 40 grains attached to the wick by a small piece of thread. When a further weight of 2 grains is laid on the butt end of the candle it will still float; but with a weight of 4 grains it will sink. As the rate of burning of a candle is affected by the force with which the wick is pulled when it is set in the mold, the strain commonly applied by an experienced maker of candles has been measured, and is found to be about 24 ounces. The candles shall be sent to the office of the Gas Referees, by whom samples from each batch will be examined and tested. Each batch of candles shall be accompanied by a specimen of the spermaceti (unmixed with beeswax) which was used in making them. Packets of candles approved by the Gas Referees will be sealed by them, and certified for use in the testing places.

5. The candles are to be used by the gas examiners as heretofore, in accordance with the half-yearly "Notifications" of the Gas Referees. The results are to be corrected as usual, on the assumption that for small variations the light of a candle varies directly with its consumption; and if any candle in a packet certified by the Gas Referees is found by a gas examiner to burn at a rate exceeding 126, or falling short of 114 grains per hour, the testings made with that candle are to be rejected.

Appendix.—Method of Determining the Melting Point of the Spermaceti.—As various methods are used by different refiners of spermaceti for determining the melting point, which lead to different results, it must be noted that the temperatures here given as the limits within which the melting point of a sample of refined spermaceti should fall—viz., 112° and 115° F.—have been found by the following method, which is known as the capillary tube method: A small portion of the spermaceti is melted by being placed in a short test tube, the lower end of which is then plunged into hot water. A glass tube drawn out at one end into a capillary tube, about 1 mm. in diameter, is dipped, narrow end downward, into the liquid spermaceti, so that, when the tube is withdrawn, 2 or 3 mm. of its length are filled with spermaceti which immediately solidifies. The corresponding part of the exterior of the tube is also coated with spermaceti, which must be removed. The narrow part of the tube is then immersed in a large vessel of water of a temperature not exceeding 100° F. The lower end of the tube which contains the spermaceti should be 3 or 4 inches below the surface and close to the bulb of a thermometer. The upper end of the tube must be above the surface, and the interior of the tube must contain no water. The water is then slowly heated, being at the same time briskly stirred so that the temperature of the whole mass is as uniform as possible. When the plug of spermaceti in the tube melts it will be forced up the tube by the pressure of the water. The temperature at the moment when this movement is observed is the melting point.

Method of Washing Wicks.—As it is found to conduce to the regular burning of candles that the wicks should have been as far as possible cleaned and freed from mineral matters, it is recommended that the candle maker, before steeping the wicks, shall wash them first in distilled water made alkaline with between 1 and 2 per cent. of strong liquid ammonia, then in dilute nitric acid containing about 10 per cent. of strong acid, and then repeatedly in distilled water.

EXHIBIT D.—*Report of the Photometric Standard Committee.* (Recommending the Acceptance of the Dibdin Pentane Air Gas Standard.) See paper by Prof. Vivian B. Lewes, "The Work of the Photometric Standard Committee."—J. of G. L., May 14, 1895.

To the Right Honorable the President of the Board of Trade—Sir: Having been constituted a Committee by the Board of Trade, on Dec. 23, 1891, "to inquire into and report to them upon the subject of the standards to be used for testing the illuminating power of coal gas," we have the honor to submit to you the following report:

1. It was intimated to us, by a letter from the Secretary to the Board, that the method at present in use for measuring the illuminative value of coal gas has been objected to, alike by the Metropolitan Gas Referees and the London County Council, as being of an unsatisfactory nature; that the London Gas Companies are alive to the defects in the present system; and that legislation is admittedly necessary for the purpose of substituting a more reliable standard for that now in existence; but that, in view of the difference of opinion as to what the substituted standard should be, the President of the Board deemed it advisable that, before his support was given to any legislation, the whole question should be considered by a committee that would command the confidence of the various interests affected.

2. The method at present in use for measuring the illuminative value of coal gas consists in comparing the light of the gas, when burning from a particular burner at a specified rate, with the light of a sperm candle burning also at a specified rate, which last is taken as a standard. We have satisfied ourselves, from considerations set forth in the appendix to this report, that the flame of a sperm candle does not furnish a satisfactory standard, by reason of the amount of light which it affords varying over a wide range, under conditions as to the manufacture of the candle, as to its mode of use, and as to adventitious circumstances attending its use, which, as a whole, it is not possible to regulate and define.

3. Though recognizing, however, that the sperm candle flame does not furnish a satisfactory standard, we nexertheless consider it advisable that, in official documents and reports, the quantity of light yielded by coal gas burned under specified conditions should continue to be expressed as heretofore, in terms of candle light, the actual comparison, however, being made between the gas light and some well defined and constant light ascertained to be equal in quantity to, or a definite multiple of, the *average* light given by the standard sperm candle.

4. We have further come to the conclusion that, in the present state or experience and knowledge, the source of the light to be used as a standard by gas testers generally, must be produced by the process of combustion, and be in the nature of a flame.

5. We find that the 1-candle light flame proposed by Mr. A. Vernon Harcourt as giving a standard light, and commonly known as the "Harcourt pentane air gas flame," when used under the conditions de-

fined, does constitute a very exact standard, capable of being reproduced at any time without variation of illuminative value.

6. We have satisfied ourselves that the light given by Mr. Harcourt's above-mentioned pentane air-gas flame as defined, in respect to the conditions of its production, in the appendix, is a true representative of the average light furnished by the sperm candle flame constituting the present standard. Since 1879, when the pentane air gas flame was first introduced, many series of experiments have been made by different observers, in which the light of the proposed standard has been compared with the light of the standard sperm candle flame, with the result that, in those series of experiments in which the height of the pentane air gas flame was adjusted strictly according to the directions given in the appendix, the light afforded by this flame was found to agree exactly with the mean result afforded by the standard candle flame. In other series of experiments, indeed, in which a slight variation was made in the mode of adjusting the height of the pentane air gas flame, some discrepancies in the direct results furnished by the comparison of its light with that of the standard candle flame were observed; but in these several series of experiments also, when the necessary correction called for by the difference in the mode of adjustment resorted to was made, the light of the pentane air gas flame was found to accord closely with the mean result afforded by the standard candle flame.

7. Inasmuch, however, as there is a practical advantage in comparing directly the light of such a coal gas flame as is usually tested (being, that is, of about a 16-candle light value,) with a light approximating somewhat in value thereto, we have further submitted to careful examination the flame of the 10-candle light pentane Argand proposed as a standard by Mr. W. J. Dibdin in 1886. This flame is produced by burning a mixture of air and pentane vapor from a suitable Argand burner, provided with an opaque screen, by which the light from the upper portion of the flame is cut off. The screen being set at a definite height, it was found by Mr. Dibdin that, owing to a compensating action affecting the lower or exposed portion of the flame, the luminosity of this portion of the flame remains constant even under considerable variations, whether in the total height of the flame or in the proportion of pentane vapor to air in the mixture burnt. With a view to simplify the construction of the Argand burner furnishing a cut-off flame of this constant luminosity, we have tried various changes in the form of the cone and in the division of the air supply to the flame, but in every case have found the original burner, as supplied by Mr. Sugg for the purpose, to give more satisfactory results than the modified forms.

8. The amount of light emitted by the portion of the Dibdin Argand pentane air flame that is used in photometry being dependent on the distance above the steatite ring of a screen by which the upper part of the flame is cut off, we have come to the conclusion that when the bottom of the screen is fixed at a height of 2.15 inches (54.6 mm.) above the top of the steatite ring, the amount of light emitted by the lower portion of the flame is substantially equal to ten times the average light of a standard sperm candle flame, or to ten times the light of Mr. Harcourt's 1-candle light pentane air gas flame.

9. We have further satisfied ourselves that any number of Dibdin Argand burners may be produced, having the form and dimensions set forth in the appendix; and that these several burners, when used in the manner there defined, may be depended on to furnish a flame giving, when duly screened at the top, ten times the average amount of light given by a standard sperm candle.

10. We therefore recommend that the pentane air flame furnished by a Dibdin Argand burner, having the form and dimensions set forth in the appendix, and used in the manner there defined, be accepted as giving the light of 10 standard candles, and that this flame be authorized and prescribed for official use in testing the illuminating power of the gas supplied by the London Gas Companies.

11. We further recommend that sealed specimens of the burner, the carburetor, and the pentane for use therewith, duly certified by the Gas Referees, be deposited with the Board of Trade, and also in such places and in the care of such persons as the Board may direct, to be available for the purpose of comparison, in the event of any question arising as to whether the pentane air flame or some particular burner does or does not afford the same amount of light as that now proposed for adoption as a standard.

12. With a view to making some provision for future possible improvements and requirements, we further recommend that the Gas Referees be authorized, should they at any time see fit, to approve and certify for use in gas testing any other flame, based upon the 10-candle standard defined above, which they may consider suitable for the purpose, whether produced in a like or unlike way, and whether having the same or a different multiple value; such other flame, however, not to be used for gas testing unless approved by the Board of Trade, and unless the gas companies give their consent to its adoption as a standard.

13. We further recommend that the illuminating power of coal gas shall continue to be recorded as heretofore in terms of the light given by a specified number of cubic feet (to wit, 5 cubic feet) burnt per hour from the standard "London" Argand burner; but that, in testing the illuminating power of the gas, the requirement that the gas shall actually be consumed at this rate be rescinded, so as to allow the Gas Referees to sanction[1] a mode of testing in which the gas shall be burned from the standard "London" Argand burner at whatever rate is found requisite in order that it may give a light equal to that of the prescribed number of candles, and in which the illuminative value of the gas shall be calculated as being inversely as the rate at which such gas had to be burned during the testing so as to give this amount of light. We have the honor to be your most obedient servants,

(Signed) WILLIAM ODLING, Chairman. WILLIAM POOLE.
W. J. DIBDIN, GEORGE ROSE-INNES.
E. FRANKLAND. A. W. RUCKER.
A. VERNON HARCOURT. W. J. RUSSELL.
GEORGE LIVESEY. G. C. TREWBY.
Subject to the omission from 13 of the words "the Gas Referees to sanction," H. E. JONES.
VIVIAN B. LEWES, Secretary.

EXHIBIT E.—*Dibdin's 10-Candle Pentane Argand Air Gas Standard.* (From the *Journal of Gas Lighting*, May 14, 1895.)

When reading his paper on "The Work of the Photometric Standard Committee," at the meeting of the Incorporated Institution of Gas Engineers last week, Professor Lewes exhibited Mr. Dibdin's 10-candle pentane Argand air gas standard, which, as will be seen by the paper, given in another part of the *Journal*, is recommended by the Committee as the standard to be used for testing gas. An illustrated description of the apparatus is given in Section IX. of the appendix to the Committee's report; and this portion of the document we have permission to reproduce.

The apparatus used in producing this standard consists of two separate portions—viz., the burner and the carburetor. The burner is a specially constructed tri-current Argand burner; the annular steatite ring being perforated with 42 holes, each hole being 0.71 millimeter in diameter. The three air currents are: (1) The central current rising inside the steatite to the inner portion of the flame; (2) a current rising outside the steatite, and caused to impinge upon the flame by an inner metal perforated and incurved cone, the top of which is level with the top of the steatite; (3) an outer current rising on the outside of the above cone, and between that cone and the glass chimney. The inner perforated cone is punctured with ten apertures 0.25-inch in diameter, which are provided for the purpose of equalizing the two outer currents of air as may be required to suit the height of the flame.

The glass chimney is carried in the groove provided on the outer cone, which answers the purpose of a gallery; the dimensions of the chimney being 6 inches high and 1¼ inches inside diameter. The top of the flame should be maintained as nearly as possible at 3 inches above the steatite; this point being indicated by the wires crossing the blue glass screens carried on each side of the burner on the metal supports. The flame is steadied by the small air-directing cone situated centrally beneath the steatite; the apex being 0.03-inch below the metal support carrying the steatite.

On the side of the burner to be presented to the photometer disc, a metal screen, 8½ inches in height, is placed and screwed securely to the base plate. The middle portion of this screen is cut away, so as to leave above the top of the steatite burner an opening 2.15 inches in height and 1.4 inches in width; the lower portion of this opening being exactly level with the top of the steatite. The light emitted horizontally through this opening by the flame produced by the combustion of the gaseous mixture of atmospheric air and pentane formed in the carburetor described below is used as the standard of light. It is equal to the light emitted by 10 parliamentary sperm candles. The lower portion of the screen has an opening 1 inch wide by 2.3 inches in height, to allow free access of air to the under portion of the burner.

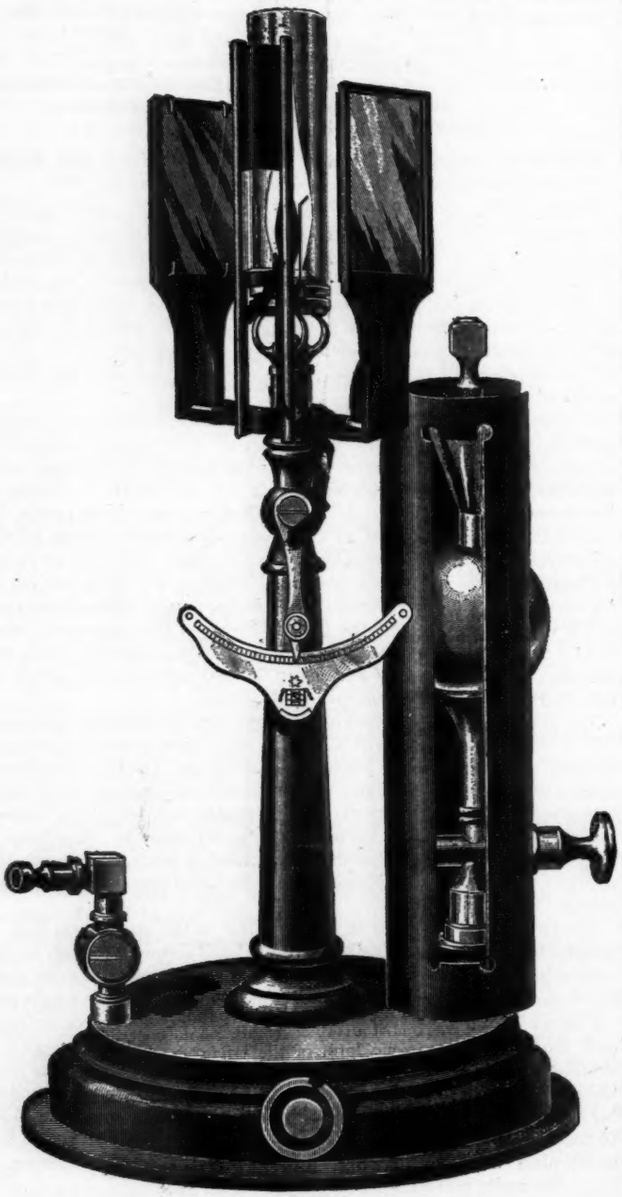
The various dimensions and arrangements of the parts are more particularly described in the following table of measurements and accompanying detailed plans.

The position of the burner in relation to the photometer disc is to be fixed by the burner fitting gas-tight into a faced joint attached to the photometer at the required point; and the burner is to be set at such a

1. These words, as will be seen by his note to the report, were objected to by Mr. H. E. Jones.

height that the center of the illuminated disc and the bottom edge of the cut-off shall be in the same horizontal plane. The length of the connection between the burner and carburetor may be varied, but should not be more than 5 feet. The center of the flame is to be immediately over the terminal point of the photometer bar.

The carburetor for the 10-candle pentane Argand consists of a circular vessel constructed of tinned plate, 203.2 mm. (8 inches) in diameter and 50.8 mm. (2 inches) in depth, having a spiral division 25.4 mm. (1 inch) in width. This division is made by soldering in a spiral strip of metal, 4 feet 6 inches in length and 2 inches wide, gas-tight, to the under side of the top of the carburetor; so that, when the top is fixed on, the bottom of the strip comes close to the bottom of the vessel, and is sealed by the pentane, so that the air has to pass over pentane for a distance of about 4 feet 6 inches, and becomes thoroughly saturated. At the end of the spiral division, near the side of the carburetor, a bird fountain is fixed for charging the carburetor, and keeping it charged at constant level with liquid pentane. The lower end of the inlet foun-

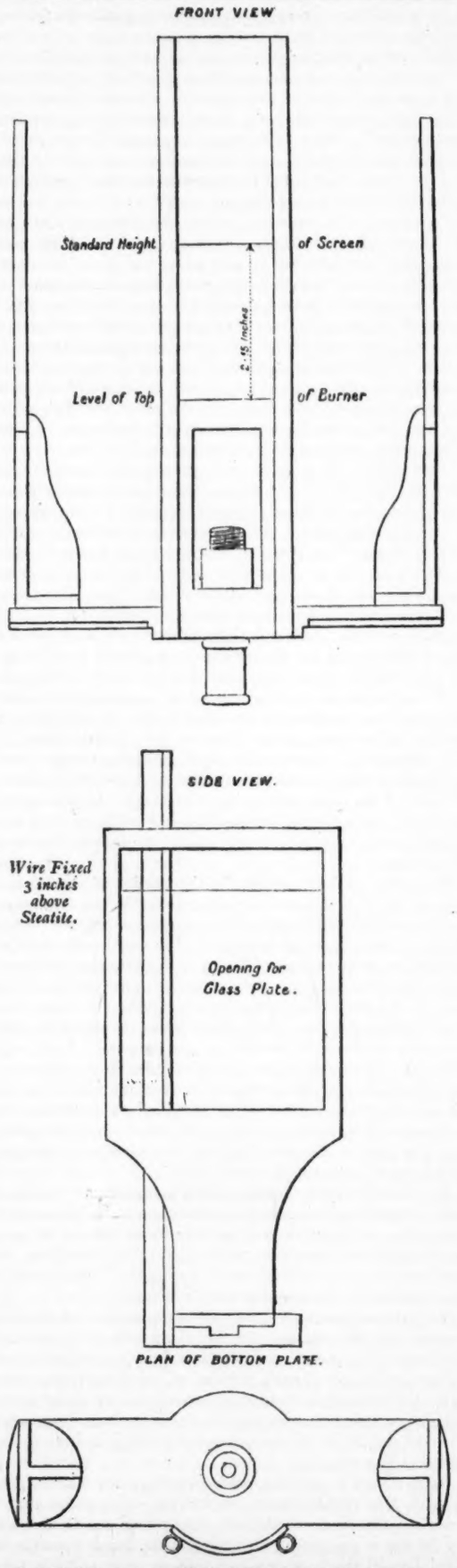


Dibdin's Pentane Argand and Carburetor.

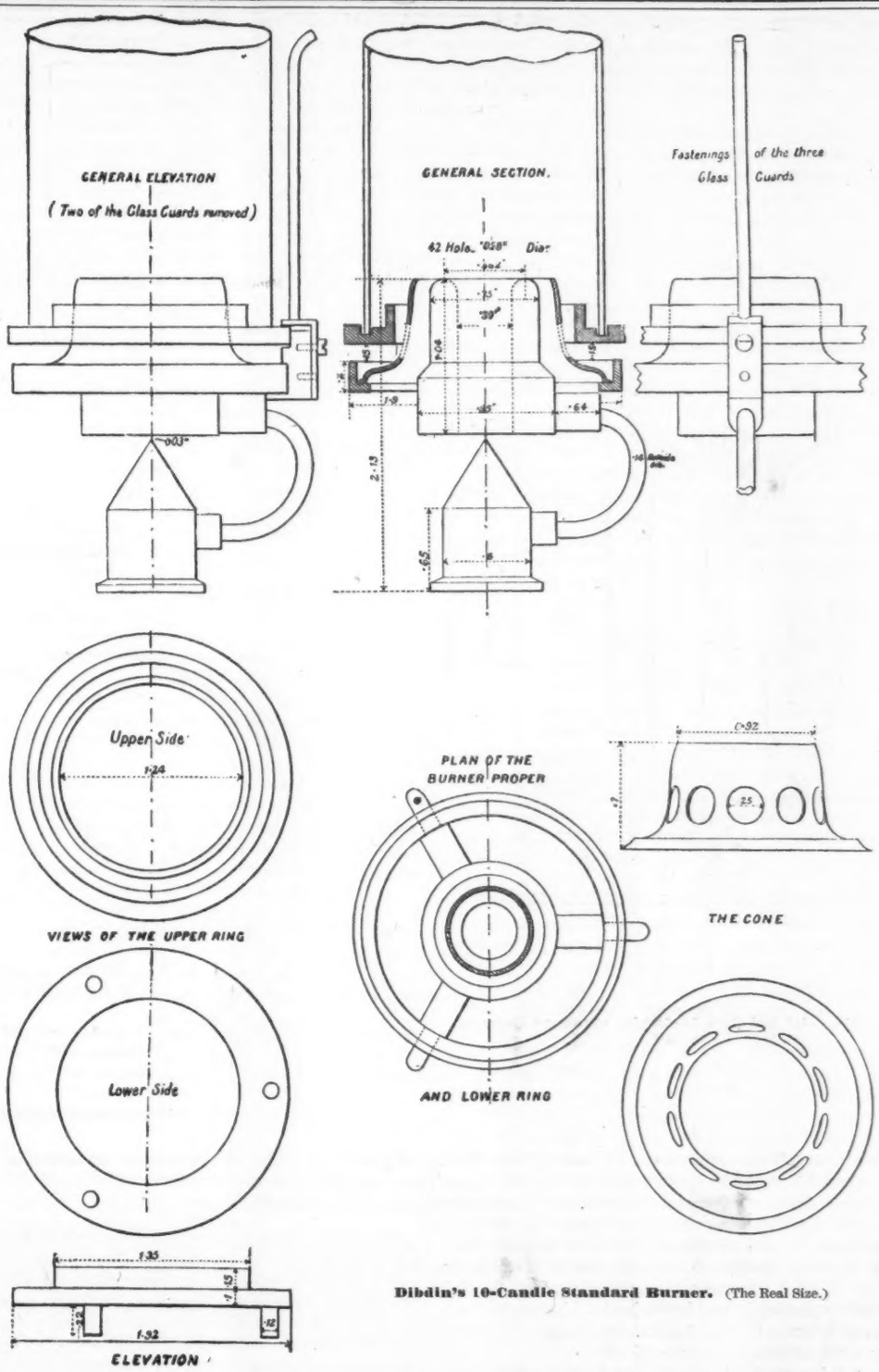
Measurements of Burner.

Number of holes	42			
Diameter of holes	0.71	mm. equal	0.028	inches.
Inside diameter of steatite	9.90	" "	0.390	"
Outside diameter of steatite	19.05	" "	0.750	"
Diameter of inside of metal cone at top	23.62	" "	0.930	"
Chimney length	152.40	" "	6.000	"
" inside diameter	38.10	" "	1.500	"
Height of cut-off	54.61	" "	2.150	"

The center of the flame to be immediately over the terminal of the photometer bar.



Framing and Screen of Dibdin's 10-Candle Standard Burner.
(One-Half the Real Size.)



Dibdin's 10-Candle Standard Burner. (The Real Size.)

tain tube is closed, and rests upon the bottom of the tank. Through the side of the tube, which is 0.4 inch (10.1 mm.) in diameter, 16 holes, 1 mm. in diameter, are bored close to the bottom, and through these the pentane enters the carburetor. At one side of the inlet tube, 1 inch from the lower end, a small tube, 3 mm. in diameter and 20 mm. in length, is connected thereto and turned upwards. The fountain inlet tube is carried up through the top of the carburetor, and continued in the form of a bulb having a capacity of about 200 c.c. Stopcocks are provided at the top and bottom of the bulb, for convenience in filling with pentane; and the portion above the upper stopcock is opened out in a funnel shape for the same purpose. When the carburetor is being charged, the gas must be extinguished, to avoid the risk of the vapor firing and causing an explosion.

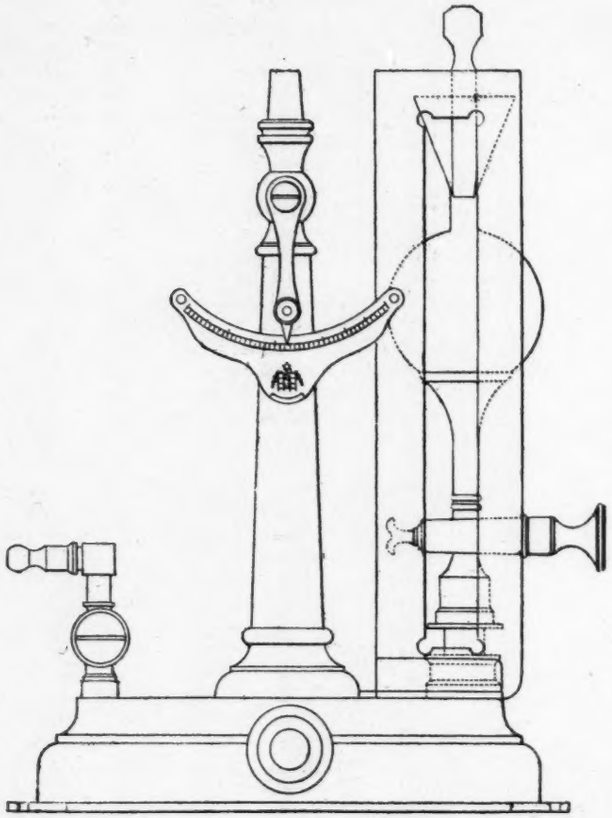
The inlet for gas or air is at the side of the carburetor, and at one terminal of the spiral division; the outlet being placed in the center of the vessel, so that the air or gas may travel over the liquid pentane throughout the whole length of the spiral division, and thus become fully charged with the volatile vapor of the pentane.

When using this standard, the pentane must be visible in the fountain bulb.

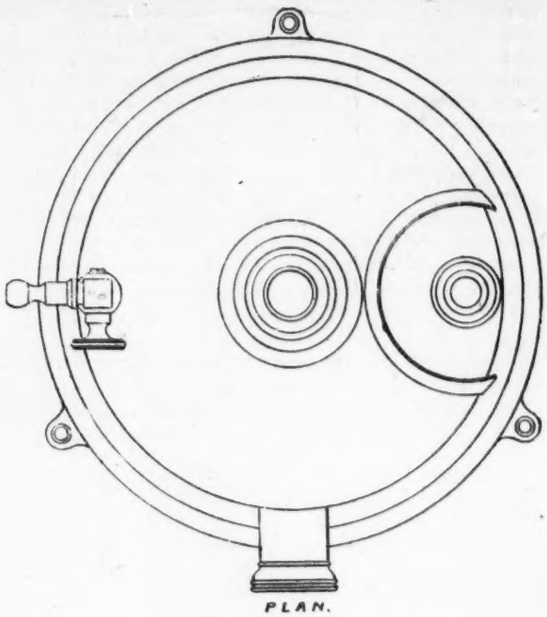
PENTANE—*Preparation and Tests.*

The following extracts from Harcourt, Lewes and Palaz may be useful for reference.

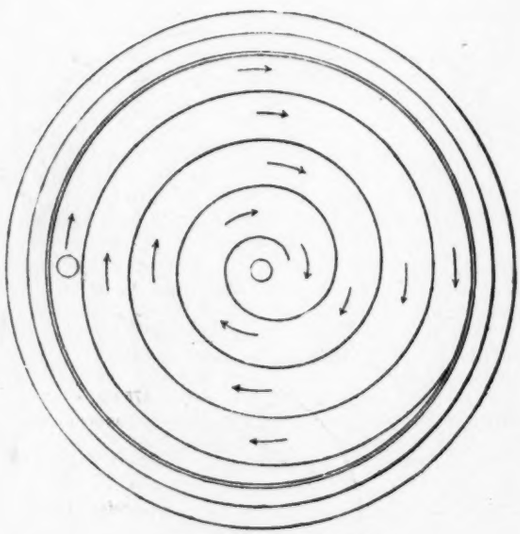
Harcourt—* * * "The liquid used for its preparation is the lightest and most volatile portion of American petroleum, obtained by purifying and rectifying in the manner already described the 'gasol n' or light



Carburetor for Use with Dibdin's 10-Candle Standard Burner.
(One-Third the Real Size.)



PLAN.



PLAN OF SPIRAL CHANNEL

petroleum procured by the air gas companies in this country from Pratt, of New York. The rectified liquid begins to distill at about 65° F., and the distillation is almost complete when the temperature of the vapor has reached 120°. The liquid consists of hydrocarbons of the paraffine series, chiefly of pentane, but with an admixture of the homologous substances tetrane and hexane. Its specific gravity varies between the limits 0.628 and 0.631 at 59° F.; but recent experiments have shown that air gas of the same illuminating power is obtained with samples varying in specific gravity between 0.614 and 0.645. The vapor of the liquid weighs 2½ times as much as an equal volume of air."

Lewes—* * * "It is prepared by distilling the light petroleum at 140°, 131° and twice at 122° F. The pentane thus prepared must satisfy the following tests: On agitation with 1-20th of its bulk of fuming sulphuric acid for five minutes, it must impart to the acid only a faint brown color. Its liquid density must be between .62 and .63 at 62° F. The liquid must evaporate absolutely without residue, at ordinary temperature, when the tension of its vapor is not less than 7.5 inches of mercury. Density of vapor compared with air must not be less than 2.47 nor greater than 2.53."

Palaz—* * * "The carburet is prepared by a fractional distillation of 'gasoline' previously washed with sulphuric acid and caustic soda. The liquid decanted is distilled four times successively at 60°, 55°, 50° C. (= 140°, 131°, 122° F.) and lastly at 50° again. The product obtained is composed of hydrocarburets of the paraffine series, $C_n H_{2n} + 2$, principally pentane, C_5H_{12}, mixed with its homologues, tetrane, C_4H_{10}, and hexane, C_6H_{14}. Its specific gravity at 15° (= 59° F.) varies between the limits 0.628 and 0.631."

[We regret very much our inability, under the ruling of the Association, to reproduce the discussion on Mr. Humphrey's paper. According to the accepted laws of the Association the JOURNAL may not take stenographic notes of anything that transpires at its meetings, and an attempt to report the substance of the discussion on this paper by ordinary longhand methods would result only in confusion and failure. This status is regrettable, for the discussion bristled with meritorious points.—EDS.]

[To be Continued.]

Purifying Gas Without Valves.

The London *Journal* says that in connection with the recent visit of the members of the Incorporated Institution of Gas Engineers to the Garston works of the Liverpool Gas Company, it should be recorded that the attention of the visitors was drawn by the Engineer of the Company, Mr. W. King, to a peculiarity of the purifying arrangements. The carbureted water gas made at these works is purified by lime, with a catch purifier of oxide. The singularity of the arrangement of the purifying plant consists in the absence of valves; their place being sup-

plied by simple siphons or U-bends in the gas mains, which can be filled with water so as to absolutely cut off the passage of gas, or emptied at will. It was explained by Mr. King that he had had so much trouble with valves in connection with sulphur purification—even those of the water-slide type—that, when it became necessary to provide purifying arrangements for the new carbureted water gas station, he decided to dispense with everything of the kind, and fall back upon the simple, positive action of a siphon. There can at any rate be no leakage of gas through such a substitute for the usual valve; and the only obvious drawback—the liability to freezing during severe weather—can, of course, be met in the ordinary way already employed in the same circumstances for the hydraulic seal of the purifier covers. It is believed that the Garston purifier house is unique in regard to the absence of valves of any kind.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

MR. HENRY C. KELSEY has been elected President of the Newark (N. J.) Gas Company, vice Mr. John L. Blake, resigned.

AT the annual meeting of the Madison (Ind.) Gas and Electric Light Company the following Directors were chosen: W. H. Powell, F. L. Powell, S. J. Smith, R. J. Graham, O. H. Cunningham, G. E. Trow and James Somerville. The Board subsequently perfected the following organization: President, W. H. Powell; Secretary, H. N. Goold; Treasurer, F. L. Powell.

THE offices of the Hackensack (N. J.) Gas Company have been removed to the Pearce building.

A CORRESPONDENT at Providence, R. I., incloses the following clipping from a recent issue of the Providence *Journal:* "An action of tort based on novel grounds is likely to be instituted by the Lynn (Mass.) Gas and Electric Company against Edward H. Oakes, a local electrician and inventor. It has been found that the supply pipe entering the house had been tapped just outside the cellar wall, which had been undermined for that purpose, and that by an ingenious arrangement of auxiliary pipes and stopcocks, hidden under the cellar floor and in hollow posts, the house was supplied with gas, of which the meter gave no sign. A small gas stove was used in Oakes' apartments, and the fuel for this had been allowed to come through the meter for the purpose, it is supposed, of allaying any suspicion in the Company's office."

THE Tax Commissioners, of Newark, N. J., have revised their valuation of the Newark consolidated gas properties. After a hearing it was decided to place the valuation at $1,475,000, an increase of about $225,000. Taking it all-in-all, the Company has been quite fairly treated.

COUNCILMAN WM. A. MILLER, of the First Ward, Philadelphia, is responsible for the introduction of the following ordinance to the Councils of the Quaker City—the ordinance was referred to the Committee on Gas:

"An ordinance to authorize a reduction in price of gas for fuel and heating purposes.

"*Whereas*, A large number of communities in the United States are being furnished with gas at a low cost for fuel and heating purposes; and as several Companies are now applying to Councils for privileges to furnish such gas to the citizens; therefore,

"This Select and Common Councils of the city of Philadelphia, do ordain that the Department of Public Works be authorized to reduce the price of gas to 75 cents per 1,000 cubic feet for fuel and heating purposes, and shall be authorized, on the application of a tenant or owner of property for the use of said gas for such purposes, to place an additional meter in the premises."

A BALTIMORE correspondent says, "that the Consolidated Gas Company will shortly begin laying mains in the Woodberry and Roland avenue districts of the Baltimore 'Annex,' an extensive section which is without gas or electric light supply. Mr. John H. Dorsey, of Roland avenue, headed the movement for the extension, which has been finally successful after many discouragements. The extension will begin at Huntingdon avenue and Oak street. Mains will be laid on Huntingdon, Cedar, Chestnut, Elm, First, Second, Third, Fourth and Fifth avenues, and out Roland avenue to the new city boundary, a distance of two miles. There are several hundred houses in this territory, for which coal oil is the only means of illumination. A large number of those residing in the district have applied for the gas service, and it is expected that it will be generally used throughout the section."

THE following is an abstract of the text of the report submitted to the Common Council of Boston, by a special committee of that body, charged with the task of considering the expediency of Boston's manufacturing and distributing gas and electric currents on municipal account:

"The first fact which is clearly apparent at the outset in investigating the subject of electric lighting is that the prices charged in various cities in this country are absolutely independent of the industrial conditions attendant upon production. Some of the greatest ranges of prices are found in cities where the actual cost of production appears to be nearly the same. Then, too, the change in price from year to year seems to be as entirely independent of industrial conditions. As an illustration, Boston was paying, in 1890, $237 a year each for its arc lights. In 1895 it was paying about $127 an arc for the same service. That there has been any change in the cost of production which would warrant such a reduction in price your committee believe to be impossible. Boston is now saving $110 per arc, or about $275,000 a year, over what it would have had to pay had the price remained the same as in 1890; but in 1890, when Boston was paying $237, it is found that the city of Cambridge was paying $180 an arc; Brookline, $182; Springfield, Mass., $218; New York, $127, and St. Louis, $75.

"The second fact that your committee find is that since 1886 about 200 cities in the United States have begun to manufacture electric light for themselves with, as far as your committee can discover, uniformly satisfactory results. Your committee is able to state that an overhead line of construction, with 35 or 40-foot cedar poles, shaved and painted, with triple braided No. 6 weather-proof line wire, including everything requisite for such service as Boston would require, can be constructed for $250 a mile. The plant in Detroit, of the finest possible make, cost $300 an arc. This includes the cost of expensive real estate, both in land and building. The actual cost of construction will not exceed $168 an arc for an overhead system of 3,000 arcs in Boston, and your committee are positive that they are not in error in making this statement. The additional cost of real estate will, of course, depend upon the location, but your committee believe that such locations can be secured as to bring the total cost of plant, including land and buildings, not over $250 an arc. Assuming that an estimate of $250 an arc is correct, the cost to the city of a 3,000 arc plant (600 lights in excess of present needs) would be $750,000. The interest on the investment, a fair charge for depreciation, and well paid labor, would, in the opinion of your committee, make the total cost not over $75 an arc, and there would be a net saving to the city of at least $125,000 a year.

"Your committee would recommend that the Mayor be requested to petition the Legislature for an amendment to the Act of 1891, whereby the city shall not be compelled to purchase the present electric light systems at a price greater than that at which they can be duplicated. That establishing and maintaining an electric light plant by the city for the lighting of its streets and public buildings would result in saving hundreds of thousands of dollars yearly is fully demonstrated by the experience of other cities in the United States. Your committee, therefore, recommend the passage of the accompanying resolves and order:

"*Resolved*, That in the opinion of the City Council the city of Boston should not pay more than $75 per arc per year for its electric lighting, pending the establishment of a municipal electric light plant.

"*Resolved*, That in the opinion of the City Council of the city of Boston, and in accordance with the provisions of chapter 370 of the Acts of 1891, and chapter 454 of the Acts of 1893, it is expedient to exercise the authority conferred by section 1 of said chapter 370 of the Acts of 1891, entitled, 'An Act to enable cities and towns to manufacture and distribute gas and electricity.'

"*Resolved*, That in the opinion of the City Council of the city of Boston, the establishment of a municipal electric light plant will result in a great saving to the taxpayers; therefore, be it

"*Ordered*, That his honor the Mayor be requested to petition the General Court at its next session for the passage of an Act that will enable the city of Boston to secure, at the earliest possible date, its electric lighting at a minimum cost."

THE people of Ludlow, Ky., want gas, and the proprietors of the Covington (Ky.) Gas Light Company are willing to pipe the streets of Ludlow, provided the authorities will grant a franchise on the following named terms: For the exclusive right to manufacture gas in Ludlow for a period of 25 years the Company will supply gas for street lighting and other public purposes at the rate of $1.25 per 1,000 cubic feet; the rates to ordinary consumers not to exceed $1.65 per 1,000 cubic feet. For the exclusive right during a term of 15 years the rates are to be $1.50 on public and $1.85 on private account.

THE Philadelphia *Press*, of the 29th October, said: "At a meeting of the Board of Directors of the United Gas Improvement Company, held yesterday, it was decided to increase the capital stock from $10,000,000 to $11,500,000, which is equivalent to an increase of 15 per cent. The action taken by the Directors was embodied in a resolution recommending that the capital stock be increased, and that the same be paid to the stockholders, who have been summoned to attend a special meeting on December 30 for the purpose of voting for or against the proposed increase. There is no doubt that the decision of the shareholders will be favorable, in which event they will receive 15 shares of the new issue for every 100 shares of their present holdings in United Gas Improvement Company's stock. In anticipation of the action of the Board the stock has advanced in price very materially, and to-day sold at 93¾, the highest price on record—the par is $50 per share. It has been rumored on the street lately that the Pennsylvania Heat, Light and Power Company was going to secure control of the United Gas Improvement Company, along with many others. President Dolan, however, of the Improvement Company, said there was no truth in the rumor. He averred that the Pennsylvania Heat, Light and Power Company could not buy or lease the United Gas Improvement Company, and there was no thought of disposing of it to anybody."

THE Dansville, N.Y., gas and electric light properties have been consolidated under the title of the Dansville Gas and Electric Light Company. The Board of Directors named comprise Messrs. Charles H. Rowe, William A. Spinning and William A. Kramer. The electric light plant will be removed from its present site close to Main street to a plot adjoining the gas works.

THE new holder for the Yonkers (N.Y.) Gas Light Company, located on Woodworth avenue near Ashburton avenue, is almost completed. Its rated capacity is 300,000 cubic feet.

THE City Gas Light Company, of Norfolk, Va., will open its new office building on Plume street about January 1st.

THE Wilbraham-Baker Blower Company, of Philadelphia, Pa., has placed its order for a new pattern storehouse with the Berlin Iron Bridge Company, of East Berlin, Conn. The building will be 64 feet wide and 86 feet long and one story high. The side walls will be of brick, covered with the Bridge Company's patent anti-condensation corrugated iron covering, and the structure will be absolutely fireproof. The Wilbraham-Baker Company reports trade as very brisk in all departments.

THE Borough Council of Hasbrouck Heights, N. J., has authorized the Hackensack Gas Light Company to place mains through the streets of the Heights.

A GAS supply is a possibility for the residents of Barre, Vt. At any rate capitalists are considering the advisability of going on with such an enterprise. Barre is situated in a similarly named township of Washington county, Vt., at a point six miles southeast of Montpelier. It is also on a tributary of the Winooski river. It sustains manufactures of iron, woollen goods and builders' hardware, is noted for its granite quarries, and is altogether a go-ahead place. Its population, however, which does not exceed 2,500, seems to us to be altogether inadequate to the fair support of a gas company.

MR. SPENCER IRWIN, of Philadelphia, has resigned from the Board of Directors of the Bay State Gas Company.

THE St. Albans (Vt.) Gas Company is quite pleased with its new office building on Kingman street.

THE first meeting of the Washington (D. C.) Board of Trade, "for the season of 1895-6," was held in the last week of October, and one of the matters to occupy its attention was a report of the Committee appointed some time ago to investigate the gas and electric lighting supply of the city. The report was mainly devoted to a history of the Washington Gas Light Company, and its tone, of course, was as antagonistic as possible to that corporation. It was claimed that the present capitalization of the Company had grown out of an original investment of $42,000, which was the only money paid in, and it was also asserted that the dividend rate for some time past had been 20 per cent. on $2,000,000 capital, together with 6 per cent. interest on $600,000 of certificates of indebtedness issued to the shareholders without cost to them. The report also dealt with the cost of gas in the District, the Committee declaring that the cost to manufacture did not exceed 37 cents per 1,000, to which should be added about 30 cents per 1,000 for distributing expenses. The Committee, of course, decided that the rate charged by the Company was excessive. It was found that the electric lighting rates were considerably higher than those charged in some other cities of the country, but it was also admitted that the rates were lower than some which prevailed elsewhere. According to the report, if the city owned the plant the cost would be much less, and that although the cost under the buried conduit system was greater than in the instance of overhead conductors, the disparity was offset by the greater safety of the underground system. From the figures gathered it looked that, under municipal ownership, the consumption of gas would be increased, largely, of course, because of a pronounced decrease in the selling rates. In fact, if the District bought the plant of the Washington Gas Light Company, at the valuation even put upon it by the Company, the District could clear $300,000 per annum, after paying interest on the money represented by plant investment. The Committee recommended that the present plants should be condemned and purchased by the district, and introduced a resolution that the Law Committee of the Board draw up a bill to be presented to Congress authorizing the purchase of the plants and providing for the raising of the necessary money. In the end it was decided to table the resolution until it had been fully considered at a special meeting.

MR. JOHN G. MATHER, Vice-President and General Manager of the Seattle (Wash.) Gas Light Company, is considering the advisability of installing a water gas plant at that point.

THE San Rafael (Cal.) Gas and Electric Light Company, acting under the provisions of the grant obtained by it last September, has begun the work of construction necessary to maintaining an electric lighting service in the nearby boroughs of Ross and Mill Valleys, Larkspur, Sausalito, Tiburon and Belvedere.

OUR contemporary *Electricity*, in commenting editorially on the chaos existing in the incandescent electric lamp trade, says: What *Electricity* predicted in the incandescent lamp business is gradually coming true, though not as rapidly as we hoped it would. We refer to the enforced retirement of the makers of inferior and cheap lamps by the working out of natural commercial laws. There have been several suspensions, none of them large enough to create any particular comment. The cutting of prices has gone far enough, however, to convince the public itself that other things than cheapness should be considered in an incandescent lamp. There never were so many poor lamps on the market, nor such a universal protest from users against them. And while the leading manufacturers are turning out better lamps than ever before, they are yet suffering from the evil effects of the competition in "cheapness." The situation, though apparently better than it was a few months ago, is critical. Some of the makers of the best lamps, exasperated at the loss of orders by the underbidding of one cent a lamp on lamps known to be worth less than half as much as their own, are seriously considering cutting the market wide open with a reduction of 50 per cent. in order to drive the trade disturbers out, trusting to an ultimate re-establishment of fair prices. We doubt the wisdom of this plan, though there appears some justification for it. The most sensible thing would be for the lamp makers to come together in some sort of a combination in which each company would preserve its individuality and work as hard to sell its own product as ever. This could be accomplished by the establishment of a central agency, from which all lamps should be billed at uniform prices for different candle powers and voltages. The selling argument would then be quality alone, and the Company refusing to go into the combination would practically confess in advance its lack of confidence in its own product. There should be in some way a general stiffening of prices, and a constant struggle to turn out the *best lamp possible*. In no other way can the incandescent lighting business hold its own against the competition of small arc lamps (constantly being improved), and against the Welsbach light, which has already made serious inroads on the income of many a central station. And it is the central station men who ought to be more interested than anyone else in improving the quality of the lamps. They do not aid in this by buying the cheapest lamp offered. The loss of a few customers by reason of poor, yellowish and offensive looking lamps will more than overbalance the saving of a few cents on initial cost. The strongest argument the central station man can offer against the Welsbach burner is the superior *quality* of the incandescent electric light. This quality is only obtainable by the use of the best lamps. The average production of lamps for this year will be about 50,000 per day. An increase in price of two cents per lamp would thus mean an added profit of $1,000 per day to divide among the various manufacturers. Lamp makers who are in the business to stay should get together on the basis of better prices and better product.

Gas Stocks.

Quotations by Geo. W. Close, Broker and Dealer in Gas Stocks.

35 Wall St., New York City.

November 4.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share.

N. Y. City Companies.	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$35,430,000	100	148⅝	148¾
Central	500,000	50	150	..
" Scrip	220,000	..	100	..
Equitable	4,000,000	100	200	201½
Bonds, 6's	1,000,000	1,000	106	..
" 1st Con. 5's	2,300,000	1,000	115	..
Metropolitan Bonds	658,000	..	108	112
Mutual	8,500,000	100	190	..
" Bonds	1,500,000	1,000	100	102
Municipal Bonds	750,000	..	..	.
Northern	150,000	50	79	80½
" Bonds	150,000	1,000	..	98
New York and East River	5,000,000	100	33	34½
Preferred	2,000,000	100	64	65½
Bonds 1st 5's	3,500,000	1,000	99½	..
" 1st Con. 5's	1,500,000	..	84	85½
Richmond Co., S. I.	348,650	50	50	..
" Bonds	100,000	1,000	..	..
Standard	5,000,000	100	70	71½
Preferred	5,000,000	100	108	..
Bonds, 1st Mortgage, 5's	1,500,000	1,000	100	..
Yonkers	209,650	50	112	..
Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	135	..
Citizens	1,200,000	20	65	..
" S. F. Bonds	320,000	1,000	..	101
Equity	2,000,000	10	..	..
" Bonds	1,000,000	..	..	..
Fulton-Municipal	3,000,000	100	175	..
" Bonds	300,000	..	103	..
Peoples	1,000,000	10	90	.
" Bonds, 7's	368,000	..	100	..
" " 6's	94,000	..	98	100
Metropolitan	870,000	100	170	..
" Bonds, 5's	70,000	..	..	..
Nassau	1,000,000	25	225	..
" Ctfs	700,000	1,000	99	100
Williamsburgh	1,000,000	50	210	..
" Bonds	1,000,000	..	107	110

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WANTED,

An Agent to Push the Sale of Gas and Cannel Coal.

One having good connection among Gas Companies and Coal Merchants. Address, stating connection and experience,

1004-3 "X. Y. Z.," care this Journal.

Position Wanted

As Superintendent or Manager.

Any kind of gas.

Address "J.,"

1065-1 Care this Journal.

Situation Wanted

By a practical man

To Take Charge of a Gas Works,

or to superintend the laying of mains, the running of services, the placing of meters, etc. Willing to begin on a moderate salary. Can furnish any reference required.

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Position Solicited

As Engineer or Superintendent of Gas Works,

By graduate Mechanical Engineer of Stevens Institute of Technology, with seven years' experience and training in the responsible management of property at the Paterson (N. J.) Gas Works. Address PAUL A. DOTY, 227 Graham Av.,

1054-tf Paterson, N. J.

POSITION WANTED

As Supt. or Manager of a Gas Works or Gas and Electric Light Works.

Fifteen years' experience as Manager of Gas Works and six years Gas and Electric Light Works. Good reasons for wishing to change present employment.

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By a man who has had a round experience in the manufacture and sale of gas,

A Position as Supt. of a Large or Small Gas Works.

Is capable and energetic, and is willing to begin at a moderate salary. Address

1062-tf "B.," care this Journal.

WANTED,

A Second-Hand Gas Engine of Some Standard Make,

that will develop from 8 to 10 horse power. Address, giving price and full particulars,

CAPITAL GAS AND ELECTRIC LT. CO.,

1065-6 Frankfort, Ky.

WANTED,

One or Two Purifying Boxes 8 ft. by 8 ft. or 8 ft. by 10 ft., with 8-in. Connections.

Give condition, with price.

THE VAN WERT GAS LT. CO.,

1064-4 Van Wert, Ohio.

FOR SALE,

Four Purifying Boxes, 8 ft. by 8 ft.,

with 6-inch Center Valves and Connections, in good order.

HOUSTON GAS LIGHT CO.,

1064-8 Houston, Texas.

Proposals for Coal Tar.

The North Adams (Mass.) Gas Light Company invites Proposals for its annual output of Gas Tar, amounting to 600 barrels. The gas made on these works is strictly produced from the carbonization of the best gas coal, no oil being used even for enriching purposes.

1064-tf F. S. RICHARDSON, Treasurer.

Proposals for Coal Tar.

OFFICE LOUISVILLE GAS CO.,
LOUISVILLE, KY., Oct. 9, 1895.

Proposals will be received until noon of Nov. 15, 1895, for the Coal Tar produced at these works on a basis of one, three or five years. Particulars as to quantity, facilities, etc., may be had on application to the undersigned.

1062-5 A. H. BARRET.

Get Our Prices on

Mica Chimeys

For Welsbach Lights,

AND ON

Mica Canopies.

The MICA MFG. CO.,

Micasmiths,

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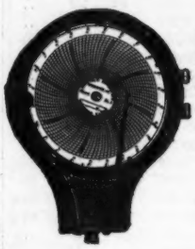

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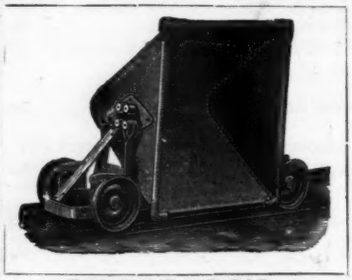

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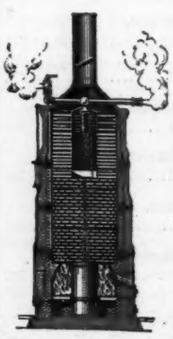

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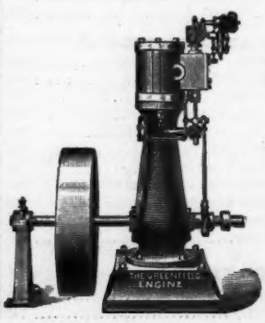

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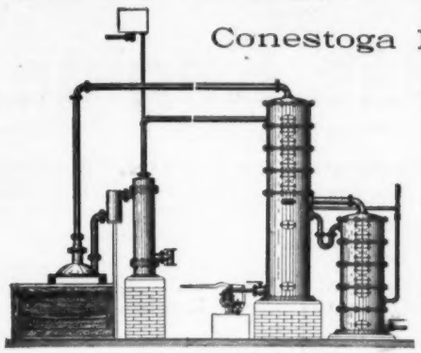

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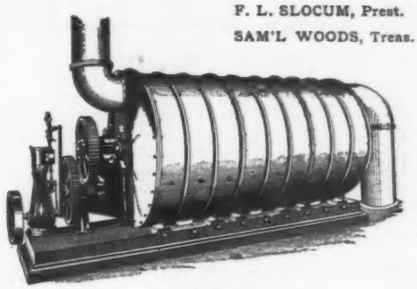

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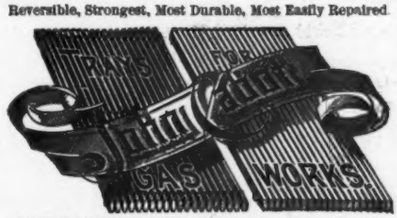

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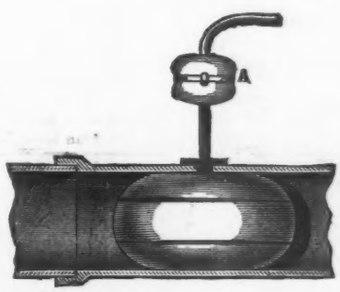

These Gas Bags are used to stop the flow of gas while repairing or making alterations in gas mains. There have been numerous cases of workmen being badly injured, and sometimes fatally, by the escape of gas resulting from the bursting of a bag, and our patent improvement is designed to obviate such calamities. The indicator *A* shows unerringly when the bag has been sufficiently inflated to pack the main, and when the pumping should be stopped. Our Bags are made of a rubber stock especially prepared to admit of great distension, and to resist the action of Oils, Gases, Naphtha and other residuum in the mains, and they are made with lapped joints, which adds greatly to their strength.

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4	"	"	.80	16	"	"	8.25
5	"	"	1.05	20	"	"	12.00
6	"	"	1.75	24	"	"	17.00
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MANUFACTURERS OF

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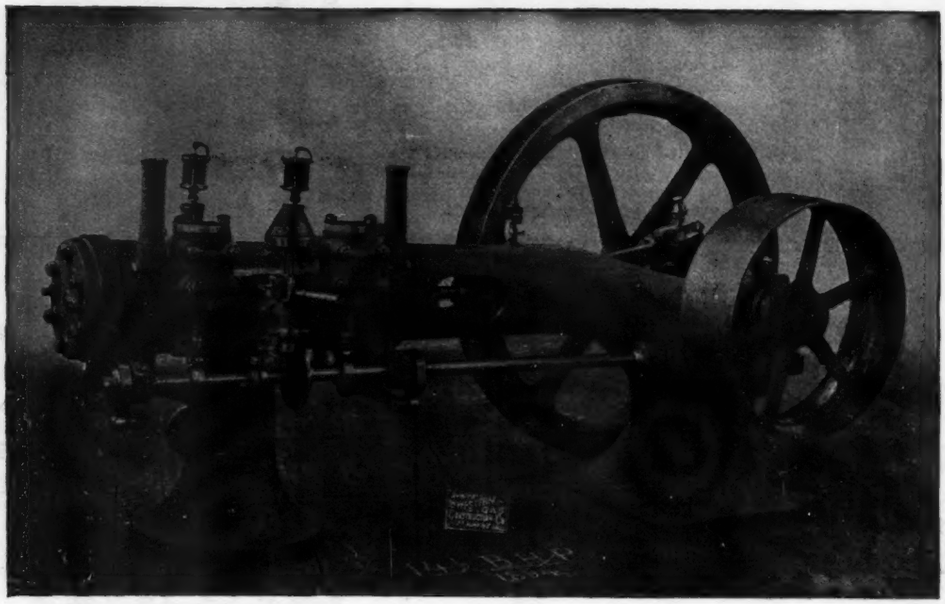
Under the Patents of Griffin, and Dick, Kerr & Co., of London and Kilmarnock.



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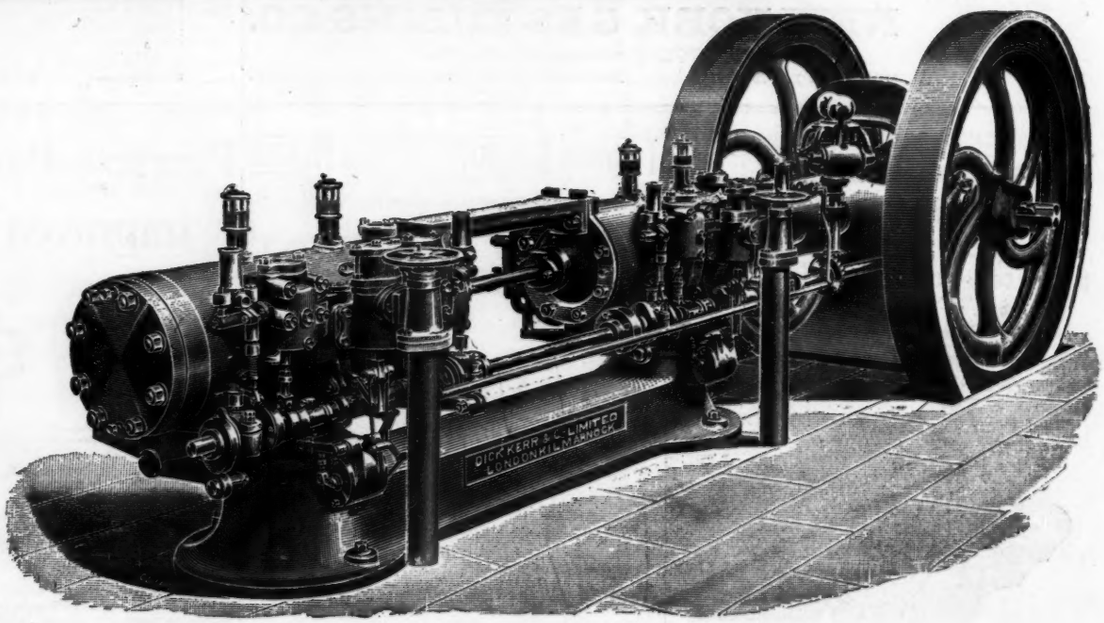
For Central Stations and all work requiring extreme steadiness.



ESSENTIAL PRINCIPLE.—An impulse at each end of piston; using half force to each impulse; doubling the steadiness; reducing the wear on moving parts, and weight for given power. **CONSTRUCTION.**—The piston rod works through stuffing box in front end of cylinder, and connecting rod is carried in a cross-head working in a slide in frame, as in ordinary steam engine practice. All valves are of the poppet type, operated by cams on a single cam-shaft, giving positive movement to every working part. Tubé or electric ignition. **RESULT.**—An engine of extreme simplicity and steadiness of action, the even wear on the cylinder and all working parts assuring increased economy, long life, and minimum cost in repairs. **RECORD.**—Successful and constant use in Great Britain for the past eight years. Address

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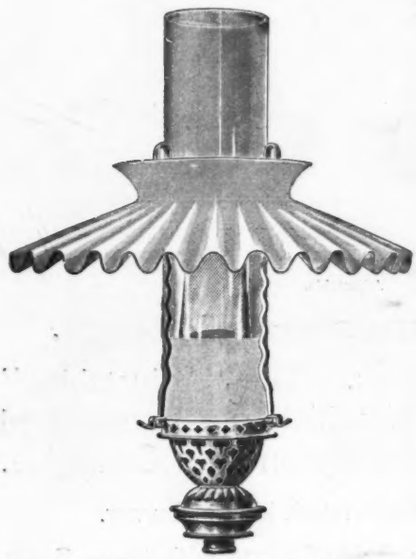

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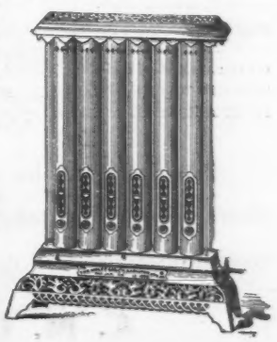
The Trilby uses less gas and gives more and better heat than any other Gas Radiator in the market.



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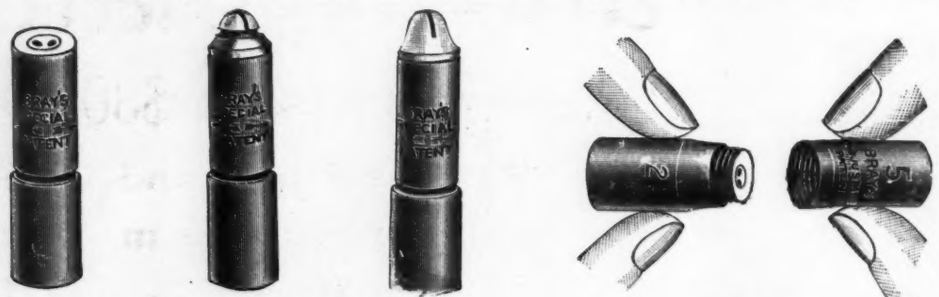

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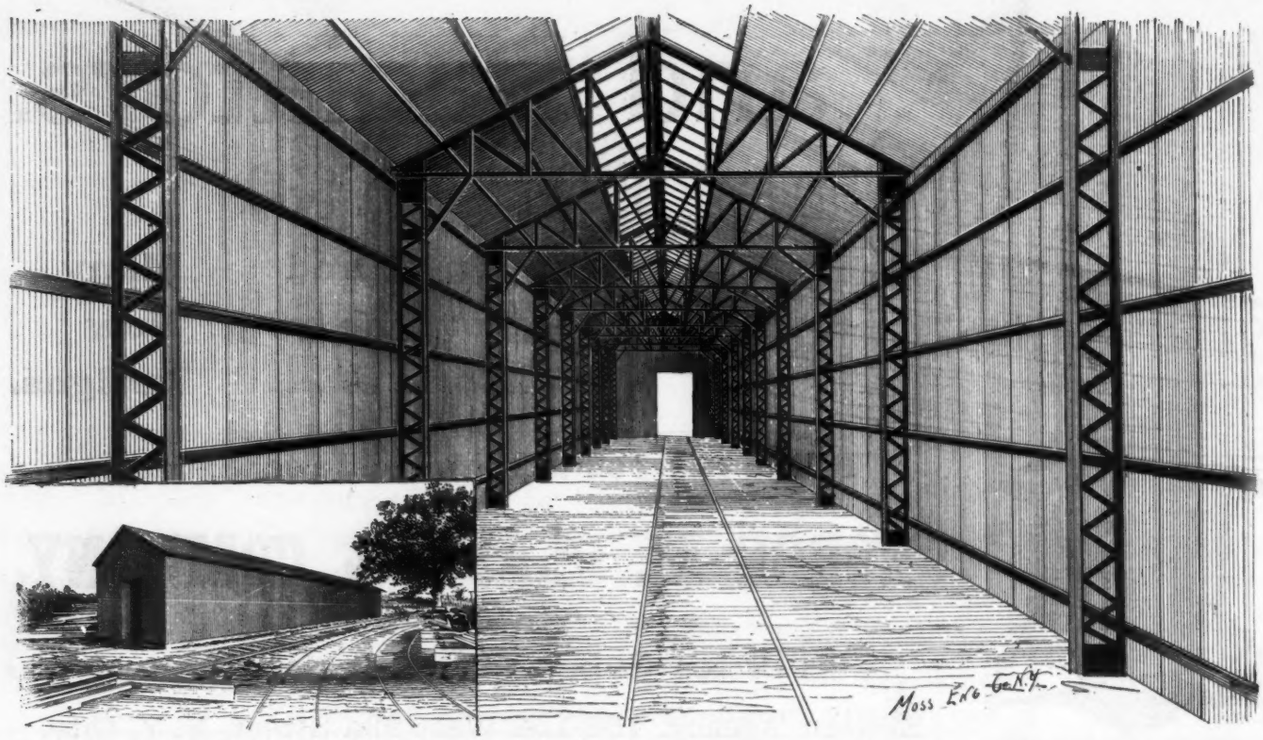

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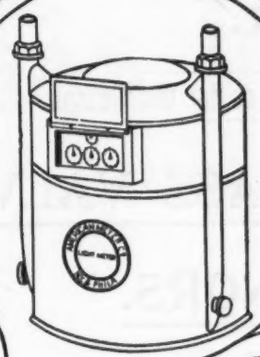

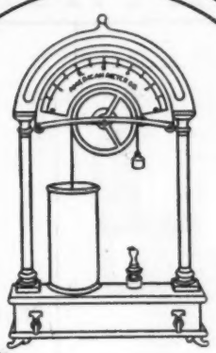

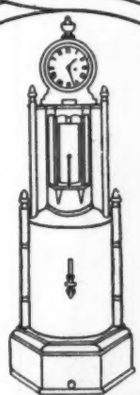

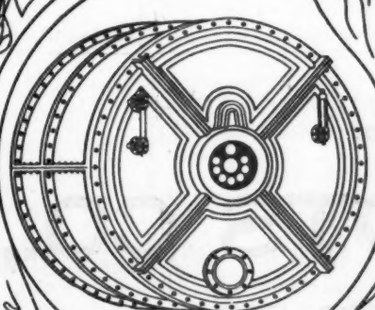

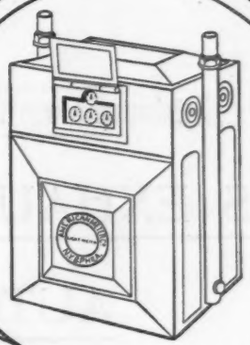

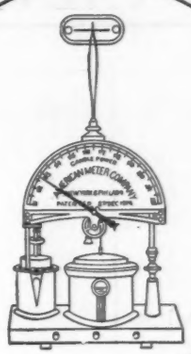

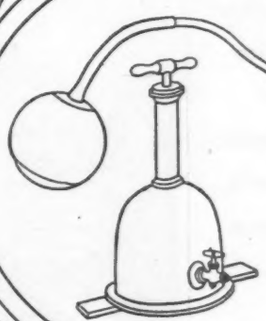

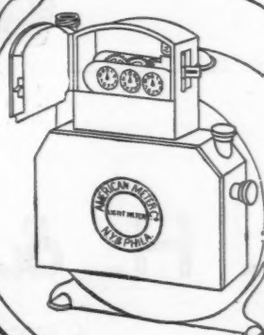

PUBLIC LIGHTING TABLE.

NOVEMBER, 1895.

Day of Week.	Date.	Table No. 1. Following the Moon. Light.	Table No. 1. Following the Moon. Extinguish.	Table No. 2. New York City. All Night Lighting. Light. P.M.	Table No. 2. New York City. All Night Lighting. Extinguish. A.M.
Fri.	1	No L.	No L.	4.45	5.35
Sat.	2	No L. FM	No L.	4.45	5.35
Sun.	3	No L.	No L.	4.45	5.35
Mon.	4	5 20 PM	6.50 PM	4.45	5.35
Tue.	5	5.20	7.40	4.40	5.45
Wed.	6	5.20	8.40	4.40	5.45
Thu.	7	5.20	9 50	4.40	5.45
Fri.	8	5.20	11.00	4.40	5.45
Sat.	9	5.20 LQ	12.20 AM	4.40	5.45
Sun.	10	5.20	1.30	4.40	5.45
Mon.	11	5.20	2.50	4.40	5.45
Tue.	12	5.20	4.00	4.30	6.00
Wed.	13	5.20	5.50	4.30	6.00
Thu.	14	5.20	5.50	4.30	6.00
Fri.	15	5.20	5 50	4.30	6 00
Sat.	16	5.20 NM	5.50	4.30	6.00
Sun.	17	5.10	5.50	4.30	6.00
Mon.	18	5.10	5.50	4.30	6.00
Tue.	19	5.10	5.50	4.25	6.00
Wed.	20	5.10	5.50	4.25	6.00
Thu.	21	8.10	5.50	4.25	6.00
Fri.	22	9.10	5.50	4.25	6.00
Sat.	23	10.20 FQ	5.50	4.25	6.00
Sun.	24	11.20	6.00	4.25	6.00
Mon.	25	12.20 AM	6.00	4.25	6.00
Tue.	26	1.10	6.00	4.20	6.10
Wed.	27	2.20	6.00	4.20	6.10
Thu.	28	3.20	6.00	4.20	6.10
Fri.	29	4.30	6.00	4.20	6.10
Sat.	30	No L.	No L.	4.20	6.10

TOTAL HOURS LIGHTING DURING 1895.

By Table No. 1.	Hrs. Min.	By Table No. 2.	Hrs. Min.
January	237.00	January	423.20
February	196.40	February	355.25
March	195.50	March	355.35
April	165.30	April	298.50
May	153.40	May	264.50
June	138.20	June	234.25
July	146 30	July	243.45
August	152.50	August	280.25
September	165.10	September	321.15
October	186.10	October	374.30
November	204.10	November	401.40
December	219.30	December	433.45
Total, yr.	2161.20	Total, yr.	3987.45

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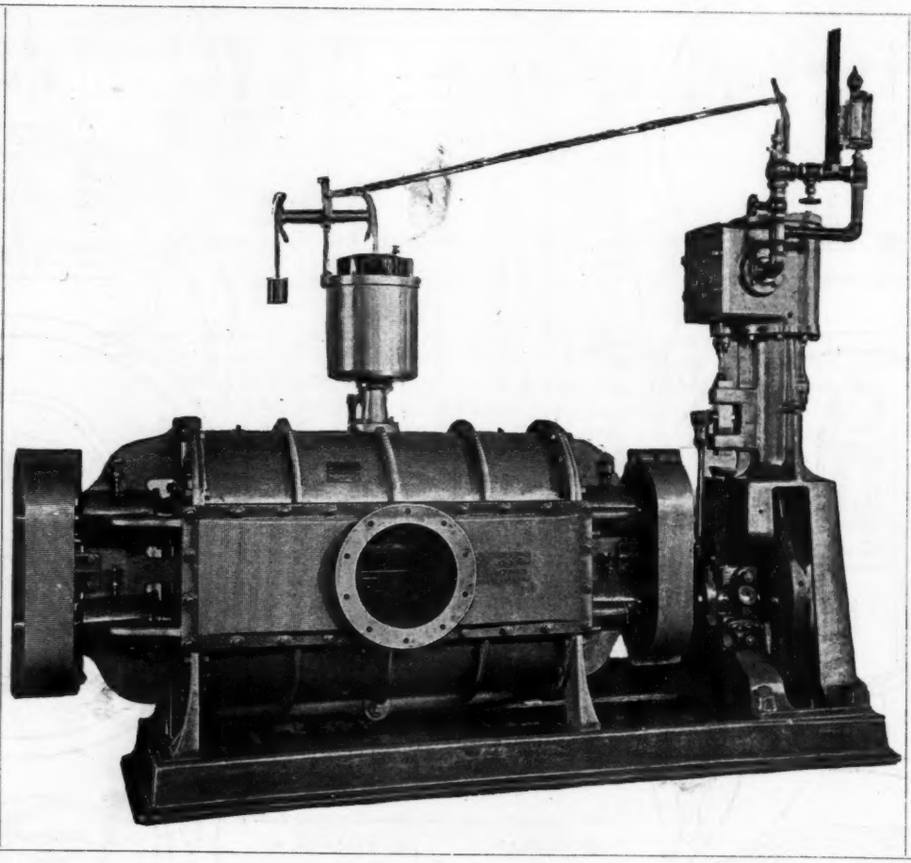

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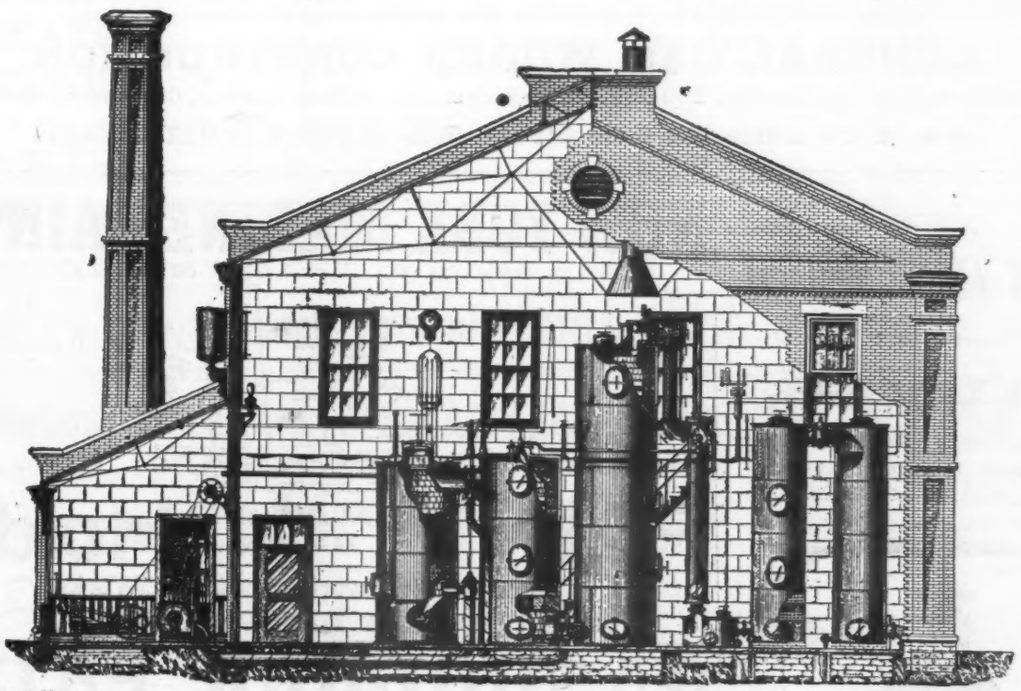

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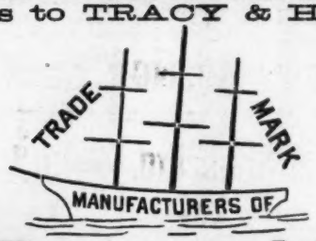

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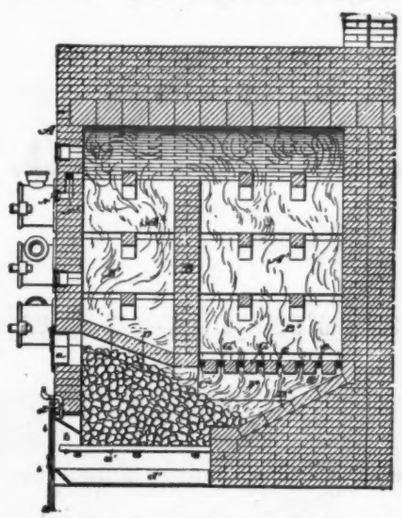

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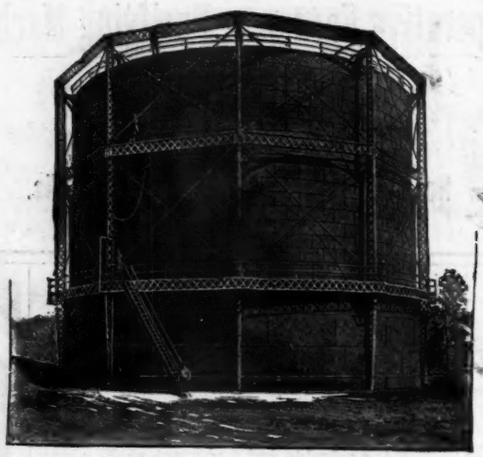

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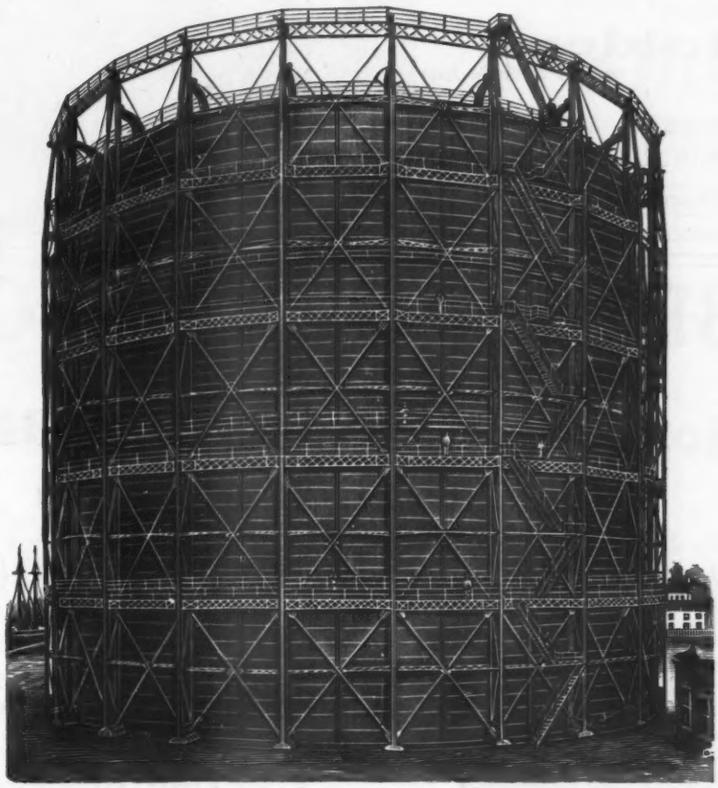

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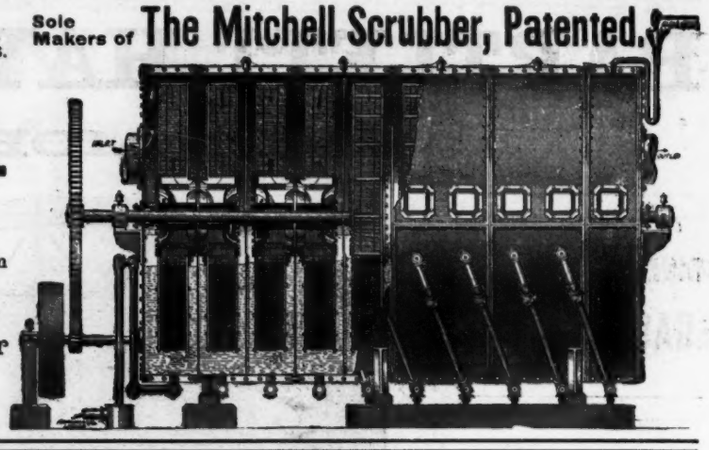

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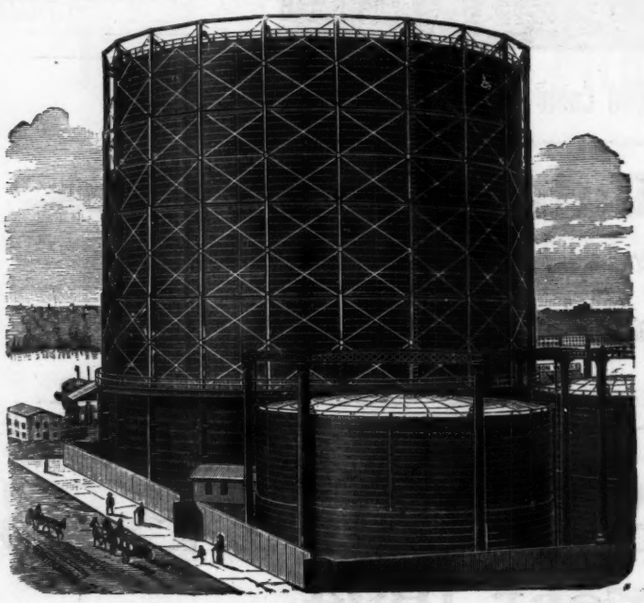

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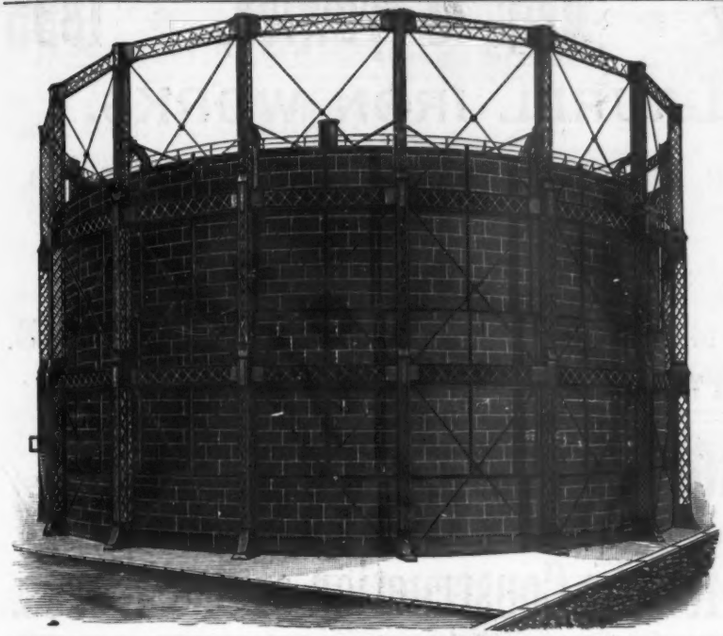

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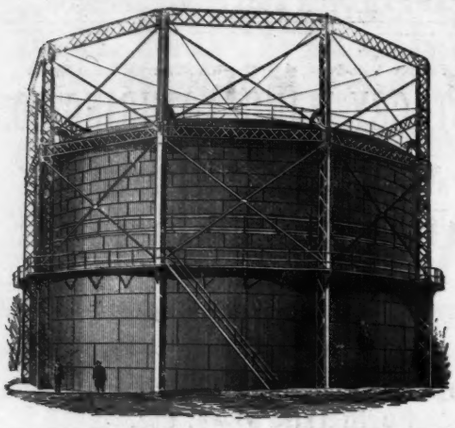

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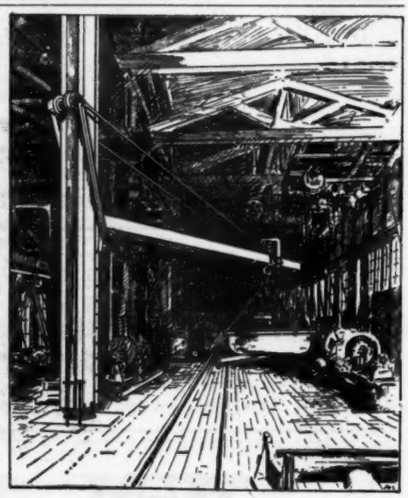

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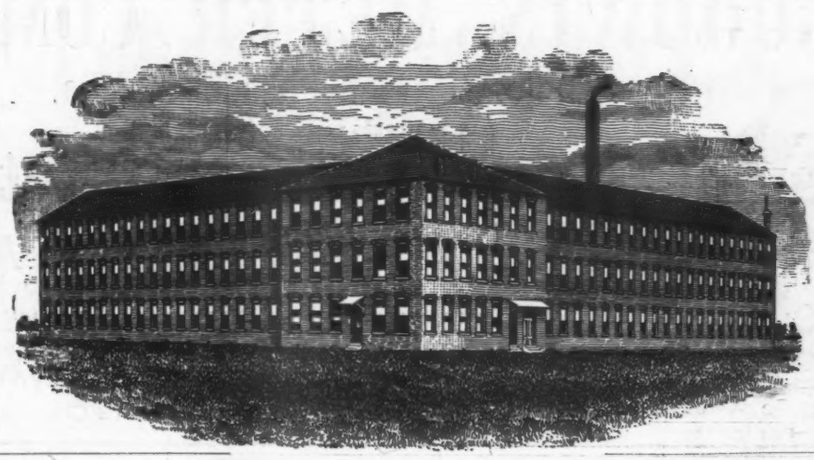

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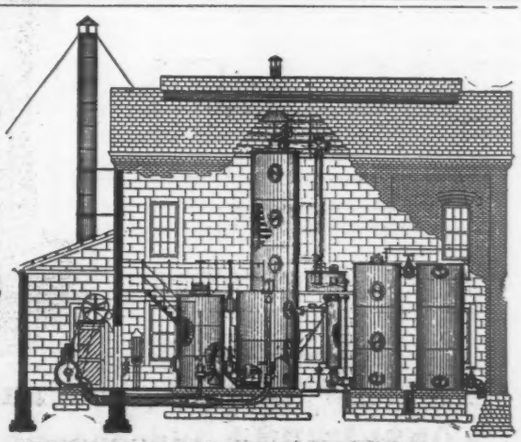

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